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AN ACCOUNT OF THE EASTERN HEMLOCK LOOPER, *ELLOPIA FISCELLARIA* GN., ON HEMLOCK, WITH NOTES ON ALLIED SPECIES

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Introduction

During the summers of 1928 and 1929 the authors had the opportunity of studying an outbreak of *Ellopia fiscellaria* Gn. in the region of the Muskoka Lakes in the province of Ontario. The results of this study are admittedly fragmentary, but in view of the fact that comparatively little is known concerning this important insect, they are presented here in the hope that the information gained may be of use to other investigators who may wish to go more thoroughly into the study of the insect, as well as to property holders whose interests are menaced by this destructive pest. Whilst *E. fiscellaria* constitutes the principal subject of the present discussion, it was thought advisable to include some notes on such allied economic species or varieties as *E. somniaria* Hulst. and *E. athasaria* Wlkr., not only because these species are often confused in reports on infestations, but also because the many obvious points of similarity both in structure and in habits existing between them suggest, at least, the possibility of certain, less apparent, biological relations.

The junior author was entrusted with the field work in Muskoka during the greater part of the summer of 1928. Most of the findings on the bionomics of *E. fiscellaria* embodied in this paper should be credited to him.

Records of Infestations by *E. Fiscellaria* and Allied Species

We have endeavoured to bring together all the available records of extensive infestations by different species of *Ellopia*. These have been taken from the published literature and from the files of the Dominion Entomological Branch, Ottawa.

The infestations are listed below in the order of their occurrence. Usually we have adhered to the text and the nomenclature used in the original reports.

1882. J. J. Walker, Ent. Month. Mag. 1888.

"At Esquimalt, Vancouver Island, in the summer of 1882, all the oaks were stripped by the larvae of *Therina fervidaria* Hbn. and their trunks and branches were paved with the handsome geometrid moths in September."

1887. Rev. G. W. Taylor, quoted in Report of the Entomologist and Botanist (Canada) 1890, p. 175.

"This year has been pre-eminently a caterpillar year, and *Ellopia somniaria* stripped the oaks. These last were very numerous, and were most disagreeable

pests, dropping from their food plant and hanging by threads, so that even in walking through the trees it was almost impossible to keep them out of one's eyes and mouth. The threads and larvae were so numerous that it was most unpleasant to walk through the oak groves, and the sound of the falling excrement was suggestive of gentle rain."

1890. Jas. J. Fletcher—Report of the Entomologist and Botanist (Canada) 1890. p. 175–177.

"Every three or four years the oaks in some districts in the vicinity of Victoria, Vancouver Island, are seriously disfigured by being defoliated by the caterpillars of a geometrid moth."

The report contains a good general account by W. H. Danby of the life-history and habits of the insect, and some remarks on the morphology, identity and control of the species by Dr. James Fletcher. Two parasites are mentioned, *Ichneumon cestus* and a *Pimpla* sp. The latter was described by Harrington as *Pimpla ellopiae*, Can. Ent. XXIV, p. 99.

1902–1903. In 1902 and 1903 several islands in the Muskoka Lakes district were severely infested by the Hemlock Looper, many trees were killed and had to be cut. The stumps of such trees could still be found in 1928. This infestation was reported orally by one of the old residents of the district.

1904–1905. Report of the Entomologist and Botanist (Canada) 1904, pp. 244–245.

"Mr. J. R. Anderson writes: 'The oak looper (*Ellopia somniaria*) appeared in vast numbers in some places on Vancouver Island this year. Strange to say, in certain localities they were entirely absent, but in others they were so numerous that they consumed every particle of their natural food, and they would then attack other trees, eating away a layer of the skin and large holes into the interior near the stem. They were also denuding the apple trees of their leaves. There were hundreds on one tree which stood beneath an oak. The larvae had defoliated the oak tree, then let themselves down in the usual manner, and were on the apple tree in hundreds eating the foliage and fruit. Other trees, as cherry, elm, etc., farther away were also attacked but not so much as those near the oaks.' *Ichneumon cestus* and *Pimpla ontario* Cress. are mentioned as parasites found in the material sent in by Mr. Anderson.

"Mr. A. W. Hanham writes: 'Victoria, B.C., October 25.—The moths of the oak looper (*E. somniaria*) have this autumn been a sight to see. Out the Cadboro Bay road large oak trees were covered with the moths a couple of weeks ago, particularly on the underside of the branches and close to the trunks. There were numbers of reddish brown ichneumons, all of one species, which were flying about the trunk of the trees.' (*Ichneumon cestus* Cr.)

Report of the Entomologist and Botanist (Canada) 1905, p. 189.

"In Vancouver Island, the oak looper *Therina somniaria* Hlst., which was complained of as being abundant last year, during 1905 swarmed in countless numbers over the oak trees in the vicinity of Victoria, B.C., and stripped them of their leaves.—*Ibid.* pp. 193–194:

"The beautiful oak trees which form such an attractive feature of Victoria, Vancouver Island, have again this year suffered severely from the attacks of the caterpillars of this Geometrid moth. It was hoped from the large number of parasites which were reared from the pupae last autumn, that the injury during 1905 would have been less than in the preceding season. These hopes, however, were doomed to disappointment, for the caterpillars occurred last spring in countless myriads and stripped every vestige of foliage from most of the oaks around the city and for several miles out into the country." A discussion of the systematic status of the species follows and *Pimpla scriptifrons* Cresson is mentioned as a parasite.

1906. S. J. Houser *Ellopia athasaria* Wlkr. Journ. Ec. Ent. XX, 2, 1927.

This author mentions the report by an eyewitness of an infestation by *E. athasaria* (?) on hemlocks in the neighbourhood of Wheeling, West Virginia.

1911–1913. R. N. Chrystal, Agric. Gaz. Canada 1916. Forest Insect Investigations in Stanley Park, Vancouver.

"The damage effected by *Therina* caterpillars to hemlock, in 1911 to 1913 was very great, whole tracts of large trees being killed and a great number of others in various parts of the park being seriously if not irreparably damaged. Observations in 1914 showed a great diminution in the number of the caterpillars, the improvement in condition being particularly marked in the case of the younger trees along the driveways, which, completely defoliated in 1913, retained their foliage in 1914, those worst affected showing signs of a return to their normal condition again. This improvement in condition consequent on the control of the caterpillars was directly due to natural causes, chiefly insect parasitism which was very noticeable in 1914, the parasite being a tachinid fly. During 1915, hardly any signs of the caterpillars were seen in Stanley Park and the present summer (1916) shows a like condition."

1912–1915. C. G. Hewitt, Dom. Ent. Report 1912.

"An unusual outbreak of a geometrid, the caterpillar of which defoliated many thousands of acres of balsam in Newfoundland was reported to us by the Deputy Minister of Agriculture and Mines for that Colony, and on investigation it was found that the insect was *Therina fiscellaria*."

J. M. Swaine—unpublished report on the Newfoundland infestation in 1925.

"We know of four areas on the Port au Port peninsula, where, during 1912 and 1915, outbreaks similar to that now in progress on Nagle's hill (*Ellopia* sp.) destroyed nearly all the fir over many square miles of country."

1919–1920. Julius V. Hoffman, U.S.D.A.B. 1200–1924. Natural regeneration of Douglas fir in the Pacific N.W.

"In 1919 and 1920, the western hemlock looper (*Therina* (*Ellopia*) *somniaria* Hulst.) killed at least 400,000,000 board feet of high quality Douglas fir and Western hemlock in Tillamook county, Oreg. The dead trees scattered through this damaged area are now a serious fire risk, and if they should burn they would not only kill much of the timber that was left unscathed by the defoliators, but would also destroy the young growth which follows in such insect-killed areas."

1920–1925. J. M. Swaine, Unpublished Report (1925) *Ellopia* sp. in Newfoundland.

"When they occur in great numbers, the caterpillars defoliate the trees over wide areas. Trees which are completely defoliated in one season die rapidly and those which are partly defoliated are weakened in proportion to the amount of foliage that has been destroyed. An outbreak of this species (*Ellopia* sp.) has been in progress in the wood adjoining the city of St. John's for at least five years, and this summer the caterpillars were exceedingly abundant throughout the area between the Golf Course and Mt. Pearl Station. A large part of the fir, and spruce mixed with the fir, has already been killed on the hill sides opposite the city. The large brownish areas are covered with dead trees. The yellowish areas indicate severe defoliation this season and include a great number of weakened trees that will unquestionably die within the next few years.

"Local outbreaks by this insect are in progress in other parts of the Avalon Peninsula . . . . It is well demonstrated, through the outbreak now in progress on Nagle's Hill and the older injuries (1912–13) that occurred in the middle and west of the Island, that we have here a very destructive and dangerous pest, capable of causing very serious injuries where the most favourable conditions for its development obtain."

1924. R. H. Pettit, Rept. Mich. St. Ent. 1926.

"During the summer of 1924, northern Michigan was the scene of a slight attack of a measuring worm, the larva of a geometrid moth. This was followed during 1925 by a far more serious attack in the course of which a very considerable number of evergreen trees in the resort district of the North were partially or wholly defoliated, resulting too often in the death of the trees. The attack seemed at that time to have centered in Leelanan County and on July 4, 1925, was well under way, the most advanced of the larvae being almost fullgrown. . . . . Five areas of severe infestation were located. In all of these the death of many trees resulted. (Leelanan Co., Grand Transverse Co., Autrim Co. (2 areas), Emmet Co.). In addition to these five severely infested areas the pests were found in Benzie, Manistee, Charlevoix, Cheboygan and Otsego Counties. The greatest injury was done wherever hemlocks abounded." *See also:* Dibble, C. B., Mich. Quart. Bull. 8, 1926.

1924–1929. Muskoka Lakes region—Discussed in present paper.

1925. S. B. Fracker and A. A. Granowsky, Journ. Ec. Ent. 1927.

"In July, 1925, the superintendent of Peninsula State Park, Door County, Wisconsin, noticed that a fine stand of hemlocks was turning brown. Upon closer observation he discovered that they were being defoliated by measuring worms occurring in great numbers. The writers investigated the conditions on July 17 and found that the measuring worms were occurring in all the hemlock stands in the park as well as in other parts of the country . . . . Judging from the effects of these larvae, hemlock trees when completely defoliated, die without being able to put out a new set of leaves.

"The state forester estimates the loss in 1925 at 6,000,000 board feet. At one point practically no hemlocks of any age are living on an area of over ten acres while a large proportion of those over about thirty acres additional have been killed." *See also* S. B. Fracker, Am. Journ. of Forestry, 1927.

L. J. Houser, Journ. Ec. Ent. XX, 2, 1927. *Ellopia athasaria* Walker. Resumé:

"This Geometrid looper appeared in 1925 attacking hemlock in eastern Ohio. A few other forest trees were injured. Defoliation killed hundreds of hemlocks—some large enough for sawlogs. Scourge disappeared in 1926 probably as a result of the fungus *Sporotrichum globuliferum* attacking the *overwintering pupae*."

1926. J. J. de Gryse, Unpublished Report, 1928. *Ellopia fiscellaria*

"Over an area about 15 miles in length, situated S.E. of Brockville on the Canadian shore of the St. Lawrence, all the hemlocks have been killed wherever they constitute a high percentage of the stands. Similar ravages are apparent on the opposite shore in the State of New York. This outbreak has been in progress since 1926."

1927. H. W. Crosbie. In correspondence, Tweed, Ont. (*Ellopia fiscellaria*).

"The area infested with these moths is situated in Clarendon Township, Frontenac County, on the north-west corner of an island in Gull Lake. The infested area is from ten to twelve acres in extent and does not appear to have increased in size since this time last year. It was first noticed by us in August, 1926, appearing from a distance to have been burned over by fire. On examination the trees were found to be defoliated and the ground covered with small hemlock needles. The moths were then present in swarms and when not flying were found on the tree trunks in bark cavities. In September of last year another visit was made to this area and although a thorough search was made no grubs or eggs could be located. This year in September the moths did not appear to be quite as numerous. Some of the trees were dead and some had started a new foliage, the needles being about half the ordinary length. This is the only area infested that I am aware of in this district and it is at least ninety miles from Brockville."

In the United States extensive infestations occurred in Jefferson County, N.Y. (U.S. Bur. Ent. Insect Pest Survey Bull., VII, pp. 341–342) and in some parts of Maine (Ibid. p. 300).

1928–1929. E. B. Watson—Unpublished report of the North Shore outbreak.

"The hemlock looper occurs in outbreak form on the North Shore of the St. Lawrence in a number of places and from sources which are considered reliable, there is every reason to believe that the insect is widely distributed and that pure stands of balsam situated between the Pentecote and Manicouagan rivers, if not already infested, are threatened with attack from the looper at some future date."

This outbreak is fully discussed by E. B. Watson in the second paper of the present series.

W. G. Mathers—Unpublished Report.

"An outbreak of *Ellopia somniaria* was found in progress at the head of the North arm of Burrard Inlet in British Columbia."

A new outbreak of hemlock looper in the balsam stands of Newfoundland was reported in 1928 by some of the limit-holders. The available details concerning this outbreak are meagre.

1929–1930. In the United States a severe outbreak of *E. fiscellaria* was reported from Pentwater, Mich. (U.S. Bur. Ent. Insect Pest Survey Bull., IX, p. 342), and an outbreak of *E. somniaria* was in progress in Willamette Valley, Ore. (Ibid. p. 346), in Amity, Ore. (Ibid. X, p. 429) and in Yamhill and Polk counties, Ore. (Ibid. X, p. 389). The principal food plant in Oregon was oak.

Several local outbreaks of *E. somniaria* were found in different parts of British Columbia. The principal host tree in all cases was hemlock. A detailed account of the outbreaks in British Columbia will be found in the paper on the Western hemlock looper by George Hopping.

Systematic Position and Principal Characteristics of the Species

The identity of the species of the genus *Ellopia*, with which this paper is concerned, has always been a moot question. In designating the species occurring in outbreak form the names *fervidaria*, *somniaria*, *fiscellaria* and *athasaria* have been employed rather indiscriminately. In the present paper we have adopted the name *E. fiscellaria* Guen. for the species occurring on hemlock and balsam fir in Eastern Canada. The species occurring on oak in Vancouver Island must probably be regarded as *E. somniaria* Hulst. The identity of the species feeding on Douglas fir and western hemlock in British Columbia is somewhat difficult to establish but, probably, it is a true *somniaria*. Hulst separated *somniaria* from *fervidaria* Hbn. mainly on colour and on the width of the transverse bands and the orange borders of the latter in the wings. The name *E. fervidaria* Hbn. cannot be applied to any of either the eastern or western forms discussed here. The forewings of the latter have distinctly angulate outer margins, whilst *fervidaria*, as figured by Hübner, has a smooth outer margin, besides possessing other characteristics such as the absence of the orange border of the transverse stripes in the wings and the smooth curve of these same stripes, which distinguish it from the typical *fiscellaria* or *somniaria*. *Ellopia athasaria* Wlkr. seems to be closer to *fervidaria* both in the shape of the wings and in the curve of the transverse stripes. Plate I, Figure 3 a–e, shows the various forms mentioned above. It would appear from Dyar's *(1)* and Houser's *(2)* statements that *Ellopia athasaria* differs in its life history as well. *E. fiscellaria* and *somniaria* overwinter in the egg stage, whilst *athasaria* hibernates as a pupa. It is not unlikely that as a

result of careful breeding experiments further light may be thrown on the systematic position of the species or forms in question.

Only three larvae of *Ellopia somniaria* from Vancouver Island and five or six larvae of the British Columbia form were available for study. The Vancouver specimens were, moreover, in very poor condition. Practically no difference could be found between these and the Eastern specimens collected in the Muskoka region. The specimens from Vancouver Island appeared to be a little larger but this may be due to artificial distention resulting from treatment in caustic potash to which they had to be subjected before they could be used for examination. The body markings visible in the specimens from Vancouver correspond in every way to those of the eastern specimens. The setal arrangement of the head, thorax, and abdomen seems also to be similar. On the other hand, all the western specimens both from Vancouver Island and from British Columbia showed a noticeable reduction in the teeth of the mandibles as compared to those of the eastern larvae. In the latter the teeth are invariably sharp and clear cut whilst in the western species the teeth are blunt and sometimes almost completely obliterated. The scarcity of available western material leaves this point more or less open to doubt, but here we have at least some indication of a possible criterion for distinction between the Eastern and Western species or forms.

Bionomics

Geological and topographical notes

The whole region of the Muskoka Lakes is precambrian and is underlain principally by granite. The fertile soil is shallow and outcrops of bare rock are to be found everywhere. The humus is very shallow in general but increases in depth in low situations and in hardwood stands. The scarcity of fertile soil is probably due to burns which occurred some years ago, humus and mineral soil being washed away by rain in subsequent years. Parts of the country recently burned over show the effect of fire and rains very plainly.

Topographically the region is fairly uniform. The country is of a rolling character resulting in a very irregular shore line and numerous islands of varied sizes. The relative elevations above the level of the lake do not exceed 150 to 200 feet.

Forest types

One may distinguish three main types of forest in the Muskoka Lakes region.

1. Old stands of hemlock, *Tsuga canadensis* (L) Carr. either pure or mixed to a small extent with white pine, *Pinus strobus* L. and different hardwoods, such as *Acer saccharum* Marsh., *Acer saccharinum* L., *Ulmus americana* L. and a few others. This type of forest is mostly over 80 years old and has not been touched by fire.

Areas covered with these stands are generally the north and northeast slopes of the low hills or parts of the mainland shore or islands where the soil moisture is comparatively high. The undergrowth in such stands is composed of ground hemlock, *Taxus canadensis*, and blueberries. In very dense stands the soil is covered with needle debris only. Natural reproduction of hemlock occurs in places where windfalls have brought in sufficient light. Good examples of this type are found on Loon, Cameron, Bell,

Governors, Elsinore Island, etc. This forest type was most exposed to the recent hemlock looper attack.

2. Old stands of white pine which cover mostly the south and southwest sides of the hills and the drier situations represent the second type. These white pine stands are also mature and suffered apparently only little from fires. A pure stand is found on Cliff Island. More frequently white pine stands are mixed with hardwoods, such as *Quercus alba* Linn., *Quercus rubra* Linn., *Populus grandidentata* Michx., *Betula lutea* Michx., *Betula alba* L. var. *papyrifera* Spach., etc.

Hemlock occurs here scatteringly only and was not attacked by the looper. In light stands the undergrowth consists mostly of blueberries whilst in dense parts the soil is covered with needle litter.

3. The third type covers land recently burned over. It consists of hardwoods with scattered hemlock and white pine. It seems to be the preparatory stage for either the first or second type. Very few old hardwood stands can be found. The type changes its composition with its age. Birches and poplars begin the process of reforestation on the bare land on account of their light seed and their ability to grow in poor soils. Maples come next in succession. Some oaks occur here and there. In moist situations these young stands are mostly so dense that no other flora is able to exist beneath them. On south slopes and in dry places this process of natural reforestation meets many obstacles. The soil is mostly covered by blueberries and weeds which are strong competitors with forest reproduction. Silver Birches Island is an excellent example of this third type of forest.

Pinus resinosa Aiton is apparently introduced in this part of the country. There is a plantation on the west shore of Cameron Island.

INTENSITY AND EXTENT OF THE INFESTATION IN THE MUSKOKA REGION IN 1928

According to information received from residents of the districts the infestation started on Morrison Island in 1925. In 1926 and 1927 Chief Island was heavily infested. There is little or no evidence for the belief that the infestation was spread by wind to other islands; it seems more reasonable to suppose that the infestation was autochtonous over the entire area and in all its parts.

In July, 1928, the percentage of killed hemlock over 3 inches DBH. ran from 10% to 100% in different localities.

In determining the grade of an infestation at the end of the season, counts of pupae found on the forest floor should furnish valuable information which might serve as the basis for a fairly exact prognostication of conditions for the coming year, with regard to both the looper population and the probable parasitism.

As no such counts had been made in 1927, twig samples were used in our study to obtain an idea of the degree of infestation. These samples consisted of 2 foot twigs which were cut off at a height within easy reach. All the larvae present on these were counted. The data shown in Table 1 were obtained from twig samples.

Since all the samples were not taken on one and the same day, there may be great differences from sample to sample in the population on the lower limbs of the trees owing to variations in weather conditions. After

heavy winds and storms the number of larvae per twig would be higher than after a series of calm days.

TABLE 1.—DEGREE OF INFESTATION AS DETERMINED FROM TWIG SAMPLES

Place	Date	No. of samples	Average No. of larvae per twig	Remarks
Cameron Island	July 4	13	35.0	
Cameron Island	July 5	22	36.0	
Cameron Island	July 10	58	26.9	
Eagle Island	July 7	20	5.4	
Chief Island	July 7	7	35.7	Southwest corner
Loon Island	July 7	8	9.0	
Loon Island	July 19	34	20.0	
Badgerow Island	July 10	10	8.7	
Badgerow Island	July 24	15	2.8	
Morris Island	July 13	25	12.6	
Mainland (East)	July 13	10	5.0	
Mainland (East)	July 23	13	6.1	
Rose Island	July 16	4	28.3	
Black Forest Island	July 16	3	11.0	
Bell Island	July 17	20	21.7	
Bell Island	July 17	31	14.45	Banded trees
Mainland (West)	July 17	27	4.3	
Elsinore Island	July 18	25	12.68	
Governor Island	July 18	25	26.3	
Laurie Island	July 19	35	7.1	
Caniff Island	July 17	10	4.2	
Mainland (West)	July 13	13	18.9	

LIFE HISTORY AND HABITS

The Eggs.—The newly laid eggs are light grass-green in colour. They measure from 0.71 to 0.96 mm. in width. They are broadly oval in shape and have a flattened area at one pole. To the naked eye the shell appears smooth, but shows fine reticulations under the microscope. After about two weeks the eggs change to a copper brown and become opalescent. Before hatching the colour becomes darker and the head capsule can be seen through the shell.

The eggs are laid either singly or in small groups of two or three on the twigs, on the needles or in the crevices of the bark of living trees. Eggs were also found on buildings, in the small cracks of shingles, on stumps and on fallen trees. Considerable difficulty was always experienced in finding eggs in nature. The insect overwinters in the egg stage.

The Larva (Plate I, Figure 1).—There are apparently five larval stages. The approximate width limits of the head capsules for each stage are given below:—

1st stage, 0.30–0.35 mm.
2nd stage, 0.44–0.72 mm.
3rd stage, 0.75–0.98 mm.
4th stage, 1.05–1.60 mm.
5th stage, 1.68–2.30 mm.

The following are the principal characters by which the stages may be distinguished.

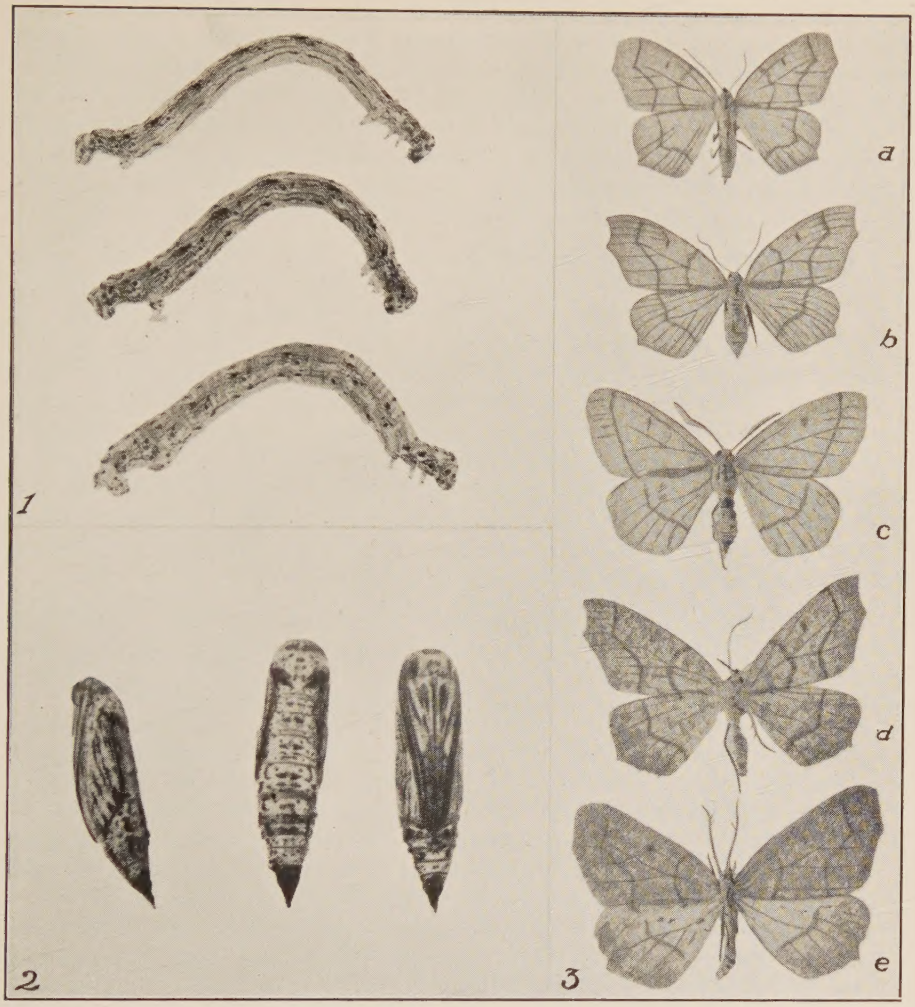

PLATE I

1. *Ellopia fiscellaria* Gn. — Different types of larvae. 2. *Ellopia fiscellaria* Gn. — Pupa. Lateral, dorsal and ventral views. 3. *Ellopia* spp. — *a* – *E. fiscellaria* Gn., male; *b* – *E. fiscellaria* Gn., female; *c* – *E. athasaria* Wlkr., male; *d* – *E. somniaria* Hlst., female; *e* – *E. somniaria* Hlst., male.

First stage larva.—The freshly emerged larva is dull white in colour with the head capsule dark brown. Two narrow dark longitudinal stripes run on each side of the body, the one is subdorsal, the other sublateral. Each thoracic segment bears a broad, dark brown, transverse band on the dorsum. On the abdominal segments similar bands encircling the entire segment occur.

Second stage larva.—The head capsule is dark brown, with light spots especially around the dark setae. The body is more greenish than in the first stage, and the markings are faint, irregular, interrupted and often confused.

Third, fourth and fifth stage larvae.—In the third, fourth and fifth stages the head capsules are of the same colour as the body. Many variations of the body colour from very pale green to dark brown were observed. The markings become more irregular and comparatively less distinct in the later stages. On the head capsule there occur brownish markings forming irregular spots around the setae. Irregular markings of a pale yellowish brown are found between the setae. The base of the body setae is usually surrounded by dark brown spots or tubercles.

Some general observations on the duration of larval stages were made both in 1928 and 1929. The observations made in 1929 relate to the early stages. Those made in 1928 relate to the 4th and 5th stages. In 1929 the larvae hatched from the eggs probably about June 10th. Up to June 17 they were practically all in the first instar. On this date the first 2nd stage larva was found. Second stage larvae began to appear in numbers about June 20. The first 3rd stage larvae were found on June 27. One 4th stage larva was found on July 2. After July 10 (1928) the number of 4th stage larvae increased gradually, reaching its peak about July 25. The last specimens of this stage were taken on August 1. There is considerable overlapping of all the stages; third stage larvae, for instance, could be found as late as the beginning of September.

The fifth and last stage is apparently the longest. The first 5th stage larvae were collected on July 19; they increased rapidly in numbers, and on August 6 more than 85% of the caterpillars were in the last stage. The length of this stage varied considerably in different individuals.

The larvae spin actively during their entire life. Threads were found all over the infested areas. After heavy winds there was a maze of threads strung between the crowns of adjoining trees. When larvae are blown off the trees they often remain suspended on their threads. A larva hanging by its spinneret is not able to grasp its thread with the prolegs. In such cases the process of reascending the thread is accomplished by means of the thoracic legs only. The thread is caught by the first pair of legs, the body is turned and twisted around to enable the meso and metathoracic legs to grasp the strand after which the thorax is stretched and the prothoracic legs again grasp the thread. The head describes a movement somewhat similar to the figure 8. The thread is rolled into a skein between the thoracic legs as the larva pulls itself up. This procedure is quite a slow one. Whenever a larva is able to reach a thread by means of its prolegs, as when crossing another thread, it begins to measure along its own thread as if walking on a plane surface. In the later stages, the larvae have a tendency to hang motionless from their threads for longer periods than in the early stages.

In the region of Lake Joseph the preferred food plant is the eastern hemlock, *Tsuga canadensis* L. The larvae destroy a considerable amount of foliage by cutting the needles near the base or by feeding on them from one side only. Needles partly destroyed in this way eventually dry up and fall to the ground. Other plants were attacked only when associated with hemlock. Larvae were found feeding on practically all trees and shrubs and many of the lower plants except ground hemlock, *Taxus canadensis* Marshall.

Rearing experiments started with third and fourth stage larvae showed that the looper larva is probably able to complete its development on a great number of food plants. All observations in the Muskoka Lakes region lead to the belief that the early stages only, namely the first and second, are restricted to hemlock as their food plant. Up to the 11th of July comparatively few other trees and shrubs were seen attacked by the looper. At the end of the larval period, end of July and first part of August, the number of other plants attacked increased steadily.

After the hemlocks, white cedar suffered most heavily from the attack of the looper. This is especially due to the character of the feeding on this tree. The small twigs are not devoured completely but cut through about $\frac{1}{2}$ to 1 inch below the end. Under heavily infested white cedar, the ground was covered with these small cuttings. On Governor's Island white cedar trees were defoliated to such a degree that their recovery is very doubtful.

Feeding on white pine was less important, but very typical. The needles are attacked from the side, and are usually not bitten through. Some very thin strands are left, which dry up, curl and give the branches a very characteristic appearance.

Juniper, spruce and the few larches seen, were attacked in the same way as hemlock. On hardwoods, irregular cuts of all sizes and shapes are made in the leaves. In some of the rearing experiments the looper larvae attacked the upper surface of the leaf-veins of different maples.

It was not possible to determine exactly which hardwoods are preferred by the looper. There was considerable variation in this respect on different islands and at different times of the season. Oaks, maples, wild cherries and blueberries were the species most commonly attacked. It was estimated that no hardwood tree lost more than about 1/20 of its leaf surface. Blueberries were the only broad-leaved plants which were completely defoliated. This was noted on several islands.

After heavy wind and rains a great percentage of the larvae are blown down from the trees. These larvae, on reaching the ground, seek the nearest tree, regardless of species, and begin at once to climb the trunk. To determine the percentage of larvae thus coming to the ground either by accident or through some other urge, 50 trees on the northwest corner on Bell Island were banded with tanglefoot on July 6. Fifty-one twig samples were taken from these and many surrounding trees on July 17. The average number of larvae per 2 foot twig on unbanded trees was 21.7 whilst the banded trees showed a population of 14.45 larvae per twig. This would indicate a difference of 20.06% in total population. This percentage would probably have been much higher had the experiment been started before the hatching of the larvae and carried on to the end of the season. The banding of trees may, therefore, be helpful in reducing the infestation on small areas.

The Pupa (Plate I, Figure 2).—Fresh pupae are light green to yellowish-green in colour, when 36 to 48 hours old they assume their final colouring which is yellowish-brown with darker markings. The length varies from 11–16.5 mm., the average of 50 measurements being 13.76 mm. In width they measure from 3.08 mm. to 4.22 mm. with an average of 3.51 mm. for 50 specimens.

In nature the first pupa was found on August 2, one day before the first pupa was obtained from cage experiments. From that time the number of pupae found and reared increased daily. Pupation was still observed on September 20, but in a few cases only. The maximum number of pupae occurred in nature during the first days of September.

Dr. Fracker found that in Wisconsin the majority of the looper larvae pupate on the trees in crevices of the bark. In the region of the Muskoka Lakes only a small percentage pupated on the trees. Before and after the finding of the first pupae, trees were climbed and examined carefully. On smooth barked trees, either no pupae at all or such a small number only could be found as to be negligible. Rough barked trees had a higher population and pupae were seen on all parts of the trunk over $2\frac{1}{2}$ inches in diameter. Crevices, loose bark and angles between the roots are the preferred places for pupation. However, more than 80% pupated on the ground, under fallen leaves, branches, small stones, in the moss and the debris. The larvae do not enter the mineral soil to pupate. On very hard ground where undergrowth is lacking and which is covered with a thin layer of duff principally composed of needles, they pupate on the surface. Buildings of any kind attract great numbers of larvae at the time of pupation. The greatest number of pupae per square yard was collected in a place protected by the overhanging of a roof. In this situation 176 fresh pupae, 2 prepupae, 1 full grown parasitized larva, 21 empty pupal skins from which moths and parasites had emerged, and 4 full grown dipterous parasite larvae were found giving a total population of 204. Such a high population is exceptional and must probably be ascribed to the protection offered by the roof. Similar figures were obtained from localities where old shingles, boards and pieces of loose bark were strewn about.

To determine the length of the pupal period, larvae and prepupae were collected and placed in vials. The first adults were obtained on the 18th day after pupation. Twenty-six days was the longest pupal period observed. In the majority of cases the pupal stage lasted between 20 and 24 days.

The Adults (Plate I, Figure 3, a–b).—In the laboratory the whole act of emergence including spreading of the wings lasted from 1 to 2 hours.

The first moths were seen in nature on August 18 on Cameron Island. On August the 19th, moths were seen on Loon Island and in the rearing experiments the first moth emerged on August 20. For a long time no females could be found in nature. From time to time collections were made to determine the sex ratio. Three hundred to five hundred moths were used for each count with the following results:—

Aug.	31	Females	3.6%	Males	96.4%
Sept.	4	Females	2.6%	Males	97.4%
Sept.	6	Females	6.0%	Males	94.0%
Sept.	11	Females	7.6%	Males	92.4%
Sept.	12	Females	11.7%	Males	88.3%
Sept.	13	Females	13.3%	Males	86.7%
Sept.	14	Females	13.5%	Males	86.5%
Sept.	19	Females	28.0%	Males	72.0%

In the rearing experiments the number of males greatly exceeded that of the females, 32.4% being females against 67.6% males. In the laboratory male emergence commenced on August 20, increasing gradually from August 25 and reaching its peak between September 3 and September 11. After the 19th of September only few males emerged. The number of emerging females began to increase 8 days later than that of the males, (September 2). The emergence reached its height between September 6 and 23. A small percentage of females was still emerging in the beginning of October. The belated emergence of the females explains the long lapse of time between the finding of the first moths and that of the first eggs.

The moths were plentiful and were found resting on trees and shrubs. They seek places which give a certain amount of protection against the weather.

During the morning hours the moths are quiescent, about noon they become slightly active, the period of their greatest activity being the evening hours.

Males kept in preserving jars and fed with sugar water lived up to 11 days, females up to 12 days.

In captivity the moths mate on the day of emergence. In some cases mating lasted from 4 to 10 minutes, in others more than an hour.

Some freshly emerged pairs were put in preserving jars with small hemlock twigs and pieces of bark for the study of oviposition.

The total number of eggs per female varied considerably although all the females were kept under the same conditions. The lowest number of eggs per female was 41 the highest 148. The average number of eggs per female, as based on these experiments, was 100.3.

Control

Natural enemies

Predators.—The predators seemed to be of minor importance in checking the looper infestation in the Muskoka region. A very few Carabids were noticed feeding on the larvae of *Ellopia*. Three different hemipterous predators were also found. These were determined by Mr. G. Stuart Walley as: *Phytocoris angustatus* Reuter, *Podisus maculiventris* Say, and *Podisus serieventris* Whler.

Parasites.—Diptera.—Four Dipterous parasites were reared from collected material and were determined by Mr. C. H. Curran as: *Winthemia* sp., *Lydella eufitchiae* Towns, *Erycia rutila* Meig, and *Madremyia saundersoni* Williston.

Probably the most important of these in the Lake Joseph region, was *Winthemia* sp.

Dipterous eggs were found on 7.04% of a number of larvae collected in different places on or before August 9, whilst pupae collected at the end of the season on Loon Island and Bell Island showed a parasitism by Diptera of 8.25% and 5.20% respectively.

Hymenoptera.—Eight different species of Hymenoptera attacked the hemlock looper in 1928: *Campoplegidea ellopiae* Walley, *Itoplectis conquisitor* Say, *Ephialtes pedalis* Cresson, *Amblyteles velox* Cresson, *Zele* sp., *Pteromalus puparum* L, *Hemiteles* sp., and *Dibrachys* sp.

Campoplegidea ellopiae was described as a new species by Mr. G. Stuart Walley in the Canadian Entomologist, Vol. LXI, p. 22, 1929. The other species were determined by Messrs. A. B. Gahan and R. A. Cushman of the United States National Museum.

An idea of the parasitism in 1928 in the Muskoka Lakes district may be gained from the conditions existing on Bell Island, where out of 800 specimens 20.12% were found parasitized, 8.25% by Diptera and 11.75% by Hymenoptera.

ARTIFICIAL CONTROL

When outbreaks of defoliating insects occur, the injury caused, especially to coniferous trees, is often fatal and it becomes imperative to have recourse to artificial control methods. In the case of broadleaf species the damage is usually not so severe and is confined to temporary disfigurement with, possibly, some loss of growth. Whether or not control measures should be applied to infested areas and to what extent the expenditure entailed is justifiable, will largely depend upon the valuation placed upon the trees. Control methods may be either *direct* or *indirect*. The first consist of emergency measures applied with a view to destroying the insects whenever they occur in outbreak form, whilst the latter, being mainly preventive in character, may be applied at any time and, if effective, should possess a more lasting value than the first.

Direct Control Measures.—1. Spraying or dusting with stomach poisons.—The hemlock looper being a leaf eating insect may readily be controlled by spraying or dusting the foliage of the infested trees with a stomach poison. There are several poisons which may be used effectively against the looper. Among these, arsenate of lead has the advantage of being simple in its application and safe against burning the foliage.

Spraying operations against the hemlock looper should be commenced as soon as the majority of the young larvae have hatched from the eggs. The period of hatching will probably vary somewhat from year to year and from region to region. For the Province of Ontario the most propitious time for spraying lies approximately between June 20 and July 15.

2. Banding the trees with sticky substances.—It is estimated that at least 30% of the loopers come to the ground at some time or another during the feeding period. If these larvae are prevented from returning to the foliage, at least a partial check of the infestation will result.

3. Dusting with airplanes.—The measures described above are applicable to small areas or isolated trees. When hundreds of acres are involved, the only effective, direct control measure is the distribution of poison dusts from airplanes. This method has been successfully applied against various insects in many parts of Europe and in 1926, it was used with good results against the hemlock looper in the state of Wisconsin. Dr. S. B. Fracker, who was in charge of these operations, states as follows: "It is estimated that in a solid hemlock stand the mortality was 90 to 95%, while in the mixed forest not less than 80%. In only one area which consisted of young hemlocks over-topped by deciduous trees and in another which was dusted just before a rain were the apparent results somewhat less than expected, with a mortality about 60%." (Jour. Econ. Ent. April, 1927).

Our own experience in Muskoka in 1928, although only a few acres were dusted, seemed to indicate that a considerable measure of success may be expected from airplane dusting, if done at the proper time.

Two areas were dusted on July 20, namely, Loon and Laurie Islands. The results of this operation were followed up as closely as possible. At the time of dusting most of the larvae had entered the fourth and quite a few the fifth stage of their development. There is not the slightest doubt that the dusting was begun at too late a date for good results. Experiments with larvae reared in preserving jars on very heavily poisoned material indicated quite conclusively that the larger larvae could withstand for a considerable time the effects of a much heavier doze than was possible or practical to apply by airplane.

Approximately 35 lbs. of calcium arsenate were used per acre. It was estimated that about 37% of the larvae were destroyed.

In 1929 airplane dusting was begun on June 19. Defects in the hopper mechanism caused several delays and regular operations were not possible until the 29th of June. The airplane used was a DeHaviland 61, equipped with a Jupiter 500 H.P. motor. It was in charge of Pilot Hector Ptolemy of the Ontario Provincial Air Service. The hopper was placed in the cabin and had a capacity of 1,400 lbs. It was made of three-ply and consisted of a rectangular box approximately $4 \times 5 \times 1\frac{1}{2}$ feet, below which a rectangular funnel reached to the floor of the cabin. The opening through which the dust was released was $8'' \times 22''$ and was fitted with a slide operated by a system of levers from the cabin of the plane. During the dusting the mechanic operated the levers of the hopper mechanism at a signal received from the pilot. This arrangement had the advantage of relieving the pilot from the actual handling of the dust allowing him to give his entire attention to the manipulation of the airplane.

The agitator was of the sliding type, shaped somewhat like the frame of a wire letter-basket and connected to an eccentric gear mounted on the lower right wing of the plane where a small propeller furnished the driving power. This worked satisfactorily for a time, after which it was discovered that the vibration of the eccentric gear was gradually weakening the structure of the wing. When this was realized, the use of the agitator was discontinued and it was found that the delivery was not seriously affected. With the agitator in action 100 lbs. of dust was released in slightly over 9 seconds, with the agitator disconnected the delivery was reduced to 100 lbs. in 12.5 seconds. At no time was there any trouble from packing of the dust within the hopper.

The poison was undiluted calcium arsenate containing 40% of arsenic oxide. Two different brands were used, each having its own advantages and disadvantages. Fifteen minutes were required to put a load of fourteen hundred pounds into the hopper. Four men were employed for this task.

Practically all the dusting was done between 4 o'clock and 8 o'clock in the morning and between 5 o'clock and 8.30 o'clock in the evening. On some dull days, dusting was continued as late as 9 or 10 o'clock in the morning. It is believed that under the conditions prevailing in the Muskoka region, slightly better results were obtained from the evening dusting than from the morning operations. Usually, there was less wind between 7

and 8.30 in the evening than at any other time of the day, and dust applied late in the evening seemed to adhere better than that applied in the morning. This may perhaps be attributed to the action of night dews, the full benefit of which was received after an evening dusting.

The area to be treated comprised parts of the mainland and a number of islands on Lake Joseph as well as several islands in Lake Rosseau. A base was established at Footes Bay and all the infested stands lay within a radius of about 8 miles from this point in a region between 50 and 60 square miles in extent. In all about 1,000 acres of woodland were dusted. In many islands, where the hemlocks covered only a part of the total area, it was necessary to treat the entire island, because the air currents and winds made the exact laying down of swaths absolutely impossible. It happened not infrequently that the drift of a dust cloud was quite in the opposite direction from the one that might be reasonably anticipated. In laying each consecutive swath the pilot was obliged to guide himself by the effect of the preceding one. As the individual areas treated were comparatively small, this could be done quite satisfactorily.

Owing to these conditions we could not determine with accuracy the amount of dust placed on any one area. Theoretically, 30 lbs. per acre was the dose aimed at in heavily infested areas. Some of these, or parts of them may have received more, others less.

Aerial photographs and large scale maps were used in determining the limits of the areas to be dusted. Owing to the nature of the region and the location of all important stands near the edge of the water, it was a simple matter to find distinct landmarks by which the pilot could be guided in his work. No flags or other markers to indicate flight lines were used. The area of a forest being estimated and the dose to be applied being decided upon, the details of the actual dusting had to be left almost entirely to the judgment of the pilot. In all areas examined, the distribution of the poison was very satisfactory. The results in caterpillar mortality were equally gratifying. In one case, where a heavy rain followed six hours after the dusting, the mortality amounted to about 80%, some forty-eight hours after the application of the poison. In areas where the dust remained undisturbed for 24 hours, a mortality of 90% to 100% was the rule.

According to reliable reports, no moths were seen in the region in September, 1929. The complete disappearance of the pest must not be attributed solely to the dusting operations. The disappearance was general in treated and untreated areas. Nevertheless, a considerable amount of damage to valuable stands of hemlock was undoubtedly forestalled by the application of the dust. All the most heavily infested territory was carefully dusted, and, it is not at all improbable that this timely treatment may have contributed considerably to an early eradication of the loopers in the Muskoka region.

Indirect Control Measures.—As has been stated in another part of this paper, stands with a higher percentage of hemlock constitute natural foci for infestations by the hemlock looper. It would appear logical, therefore, that the gradual elimination of such stands would ultimately result in the production of a forest immune to attack by the looper. Wherever

cutting operations are contemplated, the plan to be adopted would be the one which would bring about the production of a mixed stand. Local conditions must determine the method of procedure and the advice of a competent forester should be sought on these matters. In this connection the recommendations made by J. M. Swaine in Pamphlet No. 97, Dominion of Canada, Department of Agriculture, in the case of the infestation in the balsam stands of Newfoundland in 1925, are of outstanding interest.

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RESUME

Notes sur l'arpenteuse de la pruche de l'Est (*Ellopia Piscellana* Gn.,) et sur les espèces alliées. J. J. De Gryse, Division de l'Entomologie, Ministère de l'Agriculture, Ottawa, Ont.

Depuis 1882 on a signalé à maintes reprises la présence, en nombre destructeur, au Canada et aux Etats-Unis, des membres du genre *Ellopia*. Il est parfois difficile d'établir l'identité exacte de l'espèce qui est responsable de ces invasions. Il est probable que l'espèce qui se rencontre généralement dans l'Est du Canada est le *Ellopia fiscellaria* Guen. Cet insecte pullulait dans la région de Muskoka entre les années 1924 et 1929, où il a détruit des peuplements précieux de pruche (*Tsuga*) dans bien des parties de cet endroit de villégiature. Son cycle évolutif est le suivant: les œufs sont pondus vers la fin d'août et pendant tout le mois de septembre. L'insecte hiverne dans l'œuf. Les larves éclosent vers le 10 juin. Il paraît y avoir cinq phases larvaires. La transformation en chrysalide se fait en août et l'insecte parfait vole vers la fin d'août et dans le mois de septembre. Les mâles commencent à faire leur apparition quelques jours avant les femelles.

La larve dans le district de Muskoka se nourrissait principalement sur la pruche mais à mesure que la provision de son aliment végétal préféré diminuait, elle s'attaquait à presque toutes les autres espèces d'arbres et d'arbustes, à l'exception cependant de l'if, *Taxus canadensis* Marshall. L'arpenteuse de la pruche compte un grand nombre d'ennemis naturels mais l'effet que ceux-ci ont exercé sur l'invasion a été insignifiant. On est parvenu à s'en rendre maître au moyen de saupoudrages par aéroplane en 1929. La mortalité directement attribuée à l'empoisonnement à l'arséniate de calcium s'est montée à plus de 90 pour cent.

THE ECONOMIC IMPORTANCE OF PARASITOLOGY

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It is difficult to define, accurately and succinctly, a parasite. For our present purposes however, we may consider it as an organism which lives in, or on, another organism. As this would include vegetable organisms such as bacteria and fungi, which, by common consent, are now allocated to the separate sciences of bacteriology and mycology, we may alter our definition to "an animal which lives in, or on, other organisms." This definition of animal parasites is purposely vague and takes no heed of pathogenicity; this is deliberate, as we cannot always say which parasites are harmful, which are neutral and which are actually doing good to the host in which they live. We may, it is true, define as pathogenic, a parasite which causes some alteration, chemical or physical, *no matter how slight*, in the host tissue, but there is a large residuum of forms which produces no alteration which we have yet been able to detect, while in some cases, there is evidence to suggest that the parasites are actually helping in the host's economy.

Parasitism is a mode of life and is not the prerogative of any one group of animals; every group in the animal kingdom contains some parasitic members but those most prolific in parasites are the protozoa, the arthropods, and the flat and round "worms."

The protozoa are single-celled, usually microscopic, animalcules, with innumerable free-living but quite a few parasitic forms. These include the parasites of malaria, sleeping-sickness, red-water in cattle, coccidiosis and of many other diseases. The arthropods are mostly external parasites and their importance lies in their ability to carry infecting organisms from one host to another—the biting flies, mosquitoes, lice, fleas and ticks all function in this way. But this group does contain a number of true internal parasites, such as the warbles of cattle and the bots of horses, which are of very considerable economic importnce. The remaining two groups are often grouped together under the name of *helminths* or parasitic worms, but the flat-worms are quite separate from the round-worms, except in their choice of an environment. While, like both the previous groups, they contain many free-living forms, a large proportion is now entirely parasitic, no longer capable of living a free life apart from the host.

Parasitism always leads to specialization on the part of the parasite. Unused organs degenerate, used organs become enlarged or more efficient. The host supplies food and warmth, so that, in the internal parasites at least, there is a corresponding degeneration of the appendages and locomotion organs. At the same time, their generative mechanism is increased and the number of offspring multiplied enormously. This is because of the increased hazards of passing from one host to another. Many young parasites fall by the way and only a few survive to continue the race. In the course of evolution, the number of offspring produced by an adult

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parasite has been adjusted to meet the probable death-rate so that, *under natural conditions*, the egg or embryo output may be taken as inversely proportional to the chances of reaching a host. If this were not so, the parasite would either have died or would have multiplied to such an extent as to exterminate the host—and one of the fundamental tenets of parasitism is that the host should *not* be unduly harmed.

Except for the occasional case of intra-uterine infection, it is obvious that at least some part of the life of the parasite, must be passed outside of the host. This may be an adult or a larval stage—it varies considerably, but it is always constant for any given species, for parasitism is a well-regulated mode of life, governed by strict laws. Whatever stage it is, it is usually the weak link in the life-cycle and that at which the parasite can most successfully be attacked.

The protozoan parasites once they gain entrance to the body, can multiply almost indefinitely—coccidia are probably an exception to this rule, but even they can multiply to a considerable extent within the host. This means that the introduction of a single protozoan may be sufficient to cause disease, because disease always depends on numbers. In the case of the other parasites, no such multiplication within the body is possible and a single form introduced into the body remains single. It may give rise to innumerable offspring but all of these must leave the body before they can develop fully; there are no successive generations within the same host. This is a fundamental difference between the two groups. The protozoa resemble the bacteria in their methods of multiplication and attack on the host, although it is much more complicated. The remaining parasites—the Metozoan parasites as they are often called—are quite different.

Every species of vertebrate carries parasites of some sort—often a number of different species. These parasites do not, as a rule, do any great harm to their hosts. Their infective products are so widely scattered and meet such different conditions, that few of the young worms reach a host. Moreover, these parasites are all more or less specific, *i.e.*, they can develop only in a single species, or a group of closely related species of hosts. There are exceptions to this rule, however, and some of our most serious pests are among those exceptions; in general, however, the rule is true. Accordingly, the young of a sheep parasite, for example, if swallowed by, say, a horse, will not develop. These two facts explain why, although parasitism is universal, parasitic disease is not.

But, if animals (including human beings) become segregated, the infective larvae are concentrated; more and still more reach the host and develop; more eggs and embryos are passed and so the vicious circle proceeds until a state of hyper-parasitism is induced and disease and death results. This segregation may be natural, as in the great herds found in the tropics of Africa; zebra, rhinoceros, and elephants are very heavily parasitized. We see examples of it here in the "cycles" of rodents and carnivores which take place at fairly regular intervals. Owing to favourable conditions certain species of rodents increase abnormally in an area. Because of overcrowding, disease inevitably breaks out and the numbers are decimated. In due course the survivors cause another increase and so the cycles proceed. Among the major causes of these outbreaks, must be included the various internal parasites. Sometimes herd migration pro-

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tects to some extent against this hyper-infection; it is just possible that the annual migration of the North American Bison in the past permitted the herds to keep their parasites at a low ebb. A similar result is seen in animals which normally live in dens; the large cats carry a terrific parasitic burden and even such temporary habitations as birds' nests may induce a heavy infection. But as a rule segregation is artificial and the result of man's interference—either intentional or unintentional. It was intentional when he domesticated his animals or confined them in zoos or national parks; it was unintentional when he exterminated carnivores and allowed their prey to multiply, or when, by drainage and settlement, he forced birds to congregate in limited spots. He has further intensified the result of this segregation by improving means of communication so that parasites, along with their hosts, might be easily moved from one locality to another, quickly and with a better chance of successful establishment in their new environment. Let us examine what has happened and is even now happening in this respect.

The first animal to become domesticated was man himself and parasites quickly became of supreme importance in public health. Some of these parasites came from his own simian ancestors; most came from the animals he learned to tame and keep close at hand. Those bands of men who moved into temperate climates lost a number of their parasites as climatic conditions were unsuitable or as advancing civilization brought in its trail effective methods of cooking, of sanitation, of cleanliness. In civilized countries nowadays, parasites are not very common, although they do occur and parasitic disease breaks out when the least chance is given it—witness parasitic infestations seen during the late war. In the tropics it has been quite otherwise. Millions of persons are still parasitized. Malaria is still the greatest killing disease in the world; flea-carried plague annually claims its hundreds of thousands of victims; hookworm infects 60% of the earth's population and is the most important of all Imperial diseases. The great diseases of the tropics are mostly parasitic; those of temperate climates are mainly bacterial.

None of the common domesticated animals is free from parasites and all carry some of tremendous importance. The dog—probably the oldest of all—suffers severely in puppyhood from ascarids and hookworms—and these attack him from the Tropics to the Arctic. After distemper—which is even now rapidly losing its menace under scientific investigation—ascarids are the most serious of all conditions in dogs. He carries however, a large number of other parasites, which are of lesser importance only because they are more limited in their distribution.

The silver fox, the most recent of man's experiments in domestication, suffers severely from a variety of parasites. Ascarids and hookworms are among the most serious of these and many a fox-farm in Canada has been put out of business by lung-worms alone.

Cats too, suffer from practically the same parasites as do dogs, although there are quite a number of differences, and they are responsible for considerable losses in these animals.

Horses are more heavily parasitized than any other animal and practically none is free. The horse came from the dry Steppes where his parasites had learned to resist all sorts of adverse influences, such as cold and drying, and yet survive. We put him on a moist, confined field or in a warm stable where conditions for the growth of the parasites are as

nearly ideal as possible and the result has been a gross state of infestation. Now that most of the major bacterial diseases of horses are held in check, parasitism has become far and away the most important of all pathological conditions in these animals.

Sheep are in as bad a condition. It is doubtful if a single animal is free from parasites and there is no doubt whatever that they form by far the most serious source of loss to sheep farmers.

Cattle, on the whole are less seriously infected with worm parasites than are sheep. Their mode of feeding probably helps to keep these down. They do however, harbour some quite serious parasites, of which warbles are the most important.

The greatest source of loss in pigs is the large roundworm and this single species causes losses of millions of dollars yearly.

In poultry, only Bacilliary White Diarrhoea is more important than Coccidia and worms.

It is obvious, therefore, that parasitism is a serious, an appallingly serious, source of loss to stock owners. The fact that the effects of parasitism are gradual and slow in appearance makes the condition the more serious because farmers seldom suspect what it is that is gradually sapping their animals' condition, reducing their yield, hampering their natural increase and turning what should be a highly profitable industry into a most unsatisfactory business. They are familiar with the other sources of loss—nutritional and bacterial diseases. Modern research has placed the science of feeding on a sound basis and no farmer need fear the effects of unbalanced rations, or lack of vitamins or salts. Science has also laid the spectre of the great bacterial diseases, and most of these have already been conquered. But it is only in very recent times that people have come to realize the insidious, cumulative and constantly acting effects of parasites. In olden days they were probably not too great, although some, like liver-rot in sheep, have always claimed a heavy toll. It is only in modern times that they have reached serious proportions—and they are continually increasing as scientific agriculture makes it possible to keep more and more stock or any given piece of ground. The dictum that he is to be praised who makes possible two blades of grass where before only one grew, must be accepted with the greatest caution, at least so far as parasites are concerned. Thus, if a single infected sheep is confined on any given area of ground, it continually spreads worm eggs over that area. These eggs give rise to infective larvae in a week or so and are swallowed. Each one swallowed becomes adult and produces a new lot of eggs—several thousands at least. These are passed out and in due course, swallowed. If the area is small, more infective stages are swallowed; and the the smaller the area, the greater the degree of hyper-parasitism. Moreover, the sheep is compelled to continuously graze this area, thereby still further increasing the degree of infection.

So far I have been considering only domesticated animals. That is only part of the problem. Medicine has just discovered a new means of research which is called Comparative Medicine, by means of which the processes of disease are studied in all kinds of animals and even in plants. Parasitology discovered this method long ago and the study of the parasites of wild animals has been of immense service. Not only have valuable clues been found in that way—Leuckart discovered the life cycle of the guinea-worm by working on an unrelated fish round-worm—but many of

these wild animal parasites have been found to be transmittable to man or domesticated animals. In these cases the new host is often less tolerant than the old and more acute disease results. For example, African sleeping sickness of man and Tsetse-fly disease (or N'gana) of stock, is caused by a parasite of antelopes in which it causes no disease at all. Many of the round-worms of wild animals have been, and still are being, passed to domesticated forms, as man opens up new districts and introduces his own stock. This has actually occurred in Canada where a variety of forms in native ruminants have been acquired by our introduced domestic species, with very serious results.

Among other things, we find that both wild ruminants and wild carnivores act as intermediate hosts for various important human and stock worms. Moose, for example, are often infected with Hydatid cysts. These give rise to tapeworms when eaten by carnivores, which in turn may affect man with the cysts. Various wild carnivores, such as bears, often carry the Trichina worm; the flesh of such animals eaten by human beings in an undercooked or "jerked" condition can transmit the parasite to man. These two parasites by the way, are among the most serious from which human beings can suffer and it is of great importance to realize that both are present in the Dominion.

Even when they do not harbour such forms, the parasites of wild and game animals are important in themselves. Canada, with its numerous national parks and game reserves, is carrying out a system of segregation—and the usual results are accompanying this. Carnivores have been exterminated or reduced in numbers, the other animals have been allowed to multiply freely in "sanctuaries"—and parasitism has increased enormously. As Mr. Hoyes Lloyd once remarked to me "Killing-off carnivores, is one method of exterminating the other wild animals on which they prey." We can see an excellent example of this in the Red deer in Scotland. Artificial protection and the absence of all natural enemies except man, has permitted an enormous increase in numbers in the Scottish Deer Forests. The animals have decreased in quality and in size and parasitism is rife. Unless numbers are artificially decreased in the near future, that once magnificent animal is going to disappear completely. Similarly, artificial propogation and the protection afforded by the destruction of small vermin and the imposition of closed seasons, has led to serious parasitic diseases among grouse and partridges, and numbers have increased beyond the capacity of the hills and moors to support. Protection may defeat its own ends.

When agriculture advances into the wild spaces, drainage systems reduce the water area available for use by ducks and other aquatic birds; overcrowding of such lakes as are left results, and parasitism increases. Artificial bird sanctuaries are equally dangerous unless great care is taken. Disease is proportional to the numbers which congregate in them. Moreover, birds are forced to seek new forms of food and may acquire new forms of parasites, which are always more serious than their own proper ones. We actually have seen examples of this happening in Canada.

Zoos are likewise dangerous, and we have many examples of outbreaks of parasitic disease there when over-crowding takes place and sanitation is not too good. The rearing of fur-bearing animals in captivity is an industry which is just beginning in Canada. Each ranch is in the position of a miniature zoological garden and the same results follow. I have

already mentioned the case of the silver fox: the others are similar and the work of Law and Kennedy in Ontario together with our own investigations at the Institute of Parasitology, shows that all the fur-bearers carry many parasitic worms.

Among fish too, many are found heavily parasitized and quite a number of both human and animal worms are carried from host to host by these animals. Examples include the broad-tapeworm of man, which is attracting considerable attention around the Great Lakes and in Manitoba, and the liver-fluke of dogs which we are finding is not uncommon in our own North Country.

Parasitology then is a subject of enormous importance, not only to Canada but to the rest of the British Commonwealth and the world in general. Its study has permitted the opening of the tropics and is making them safe for the white man. If less important in temperate climates to human beings personally, they are more important to his stock—stock in the tropics is, on the whole, widely scattered. They are the greatest source of loss in horses, sheep and pigs; they cause millions of dollars damage annually to cattle; they are very serious pests in poultry, dogs, foxes and cats. They are equally serious in captive wild animals on ranches and in zoos; they can do great damage in national parks and they play a considerable part in the mechanism of the cycles of rodents and fur cycles. All this is the more important because bacterial and nutritional diseases are on a fair way to be brought under complete control.

The Veterinary Public Health Service has done much to bring this about and in no country is it more efficient than in Canada. Watson's epoch-making work here abolished dourine in horses; most of the great epizootic plagues have been banished from the Dominion while bovine tuberculosis is on a fair way to being exterminated; but as yet we have taken few steps to control the parasitic diseases. I am well within the truth when I say, that parasitism is now by far the most important condition in our stock. I must not be interpreted as saying that Canada has not produced any one interested in Parasitology—I have only to mention such names as Osler, Evans, Todd, Watson and Hadwen to refute that suggestion—but few attempts have yet been made at control.

This is the state of affairs which led to the establishment of the Institute of Parasitology in McGill University at Macdonald College. The initiative came from the National Research Council and it was supported, in its beginning, by the Empire Marketing Board, as it was realized that the subject is one which affects the whole British Commonwealth. The Institute is governed by a joint committee of the National Research Council and the University, with the President of the Council as its Chairman. As Director of the Institute, I hope I may be allowed to say, that it is owing to the more than sympathetic control by that Committee that the work of the Institute is progressing so smoothly. All concerned have co-operated in every way to make this possible, as indeed have innumerable Government Departments, both federal and provincial, and many other public bodies and corporations. This co-operation makes the future work of the Institute most promising.

We have divided our work into three divisions which have no very hard and fast lines between them: information, research, and teaching.

At present the last is the least important and only post-graduate students are received. Two parasitology degrees have been instituted at

McGill—an M.Sc., and a Ph.D.—and while only a very few students are under instruction at present, as the accommodation is increased and as recovery advances, there will be more. In parenthesis, I might mention that the Institute has one of the most representative teaching collections of parasites available anywhere.

Research is our most important activity and we have divided this into four groups: zoological (dealing with identifications, systematics and bionomics of parasites); veterinary (dealing with pathology and therapeutics); agricultural (dealing with control measures); and biochemical (dealing with the physiology of parasites and host resistance). At present these divisions are not in full activity but as the staff increases, the present workers will become more specialized. In addition to this, all members of the staff are engaged on a survey of the parasites of animals in Canada. This is mainly, but by no means exclusively, concerned with economically important animals and is the first comprehensive attempt ever made to place knowledge of the the parasites in a country on a strictly scientific basis. In this survey, we are receiving a great amount of assistance from various government departments (especially the Health of Animals Branch, the Parks Branch, the North West Territories Branch, the Royal Canadian Mounted Police, the Department of Indian Affairs and the National Museum), as well as from the Hudson's Bay Company and other private corporations and individuals throughout the Dominion.

The information Service is rapidly completing its organization. We have a small but useful library in the Institute supplemented by a card index summary of all papers on parasites published since January, 1932. We are receiving great assistance from the Imperial Bureau of Agricultural Parasitology in England and from the Information Division of the National Research Council. In this way, we are utilizing what has already been published elsewhere in solving our own problems and in keeping our agriculturists informed of what steps even now may be taken to reduce losses due to parasites.

The Institute, as I mentioned above, while primarily Canadian in its outlook, does not propose to be exclusively so. It was intended to help in the work throughout the whole Empire and it is already receiving material from many other parts abroad, especially from Bermuda, the West Indies and British Guiana which, as you know, are of especial interest to Canada.

Our present plans are also our future ones. As the present building, which has been donated by the Quebec Government, is enlarged and as funds become available, we hope to develop the work along the lines I have mentioned above. Canada, with its wide geographical and climatic conditions, is eminently suitable for this type of work, and we hope that soon it will lead the Empire.

My friend and colleague, Dr. Maurice C. Hall, Chief of the Division of Zoology of the U.S. Bureau of Animal Industry, in discussing parasitism, recently declared that mankind is losing the war against live-stock parasites. While this is true, we have by no means lost it yet. The war has really only now commenced. We believe that the fundamental work which is being done will provide much needed ammunition and that once the public is aroused to the insidious and dangerous nature of the "enemy within our gates," it will order a general mobilization and quickly bring these parasites within effective control.

SIGNIFICANCE DETERMINATION NUMBERS

NUMBERS OF INDIVIDUALS REQUIRED AT DEFINITE ODDS TO SECURE STATISTICAL SOUNDNESS IN EXPERIMENTAL TRIALS

S. Bird and H. S. Gutteridge
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[Received for publication May 10, 1934]

The table here presented shows the number of individuals necessary, in each of two experimental groups, to reduce the probability of any given difference occurring by chance alone to five per cent (P = .05). The coefficient of variability, as well as the difference which it is desired to demonstrate, must be known. Conversely, given a definite number of individuals for two experimental lots, and with a reasonably safe estimate of the Coefficient of Variability to be expected, the necessary per cent difference that is required between the two mean observations in order to establish with odds of 19 to 1 that such difference is due to the experimental treatment accorded them and not to chance alone, may readily be determined from this table.

The table shows the necessary number of individuals left for comparison at the end of a test. The numbers required at the beginning will consequently have to be increased proportionately to any losses that may be expected to occur during the test.

The single units of such lots will necessarily have to be drawn from the same universe, and will consequently, in probably all cases, have to be of the same sex, as sex-different response to experimental treatment would produce either a bimodal or a skew distribution, to which the ordinary measures of variability could not be applied.

Determination of the numbers required was derived from the formula for the Standard Error of the difference

$$\sigma_d = \sqrt{\frac{{\sigma_1}^2}{N_1} + \frac{{\sigma_2}^2}{N_2}}$$

and from the $\frac{\bar{x}}{\sigma}$ value for the odds required. These calculations were checked by the method employing the t values of R. A. Fisher, *Statistical Methods for Research Workers* (1925. Oliver and Boyd). All numbers below 31 were calculated by this latter method.

A random calculation of the numbers required is given herewith, assuming a Mean of 300, a C.V. of 10, and a Difference between means of 4%.

$$M_1 - M_2 = 4\%\ M \qquad M_1 - M_2 = \frac{4}{100} \times 300 \qquad M_1 - M_2 = 12$$

$$\frac{\sigma}{M} \times 100 = 10 \qquad \frac{\sigma}{M} = .10 \qquad \frac{\sigma}{300} = .10 \qquad \sigma = 30$$

TABLE OF NUMBERS OF INDIVIDUALS NECESSARY IN EACH OF TWO LOTS TO SECURE ODDS OF 19 : 1 THAT A DIFFERENCE BETWEEN MEANS IS NOT DUE TO CHANCE ALONE

DIFFERENCE BETWEEN MEAN OF EXPERIMENTAL AND CONTROL LOTS IN PER CENT: $\frac{M_1 - M_2}{\frac{M_1 + M_2}{2}} \times 100$

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
20												7	7	8	8	9	10	10	11	12	13	14	15	16	17	18	20	21	23	24	25	26
19											6	7	8	8	9	10	10	11	12	13	14	15	16	17	20	21	22	23	25	26	27	28
18										6	7	8	8	9	10	10	11	12	13	14	16	17	18	20	21	23	24	26	27	28	29	31
17										7	8	8	9	10	11	12	13	14	15	16	17	18	21	22	24	25	27	27	29	31	31	32
16									6	8	8	9	10	11	12	13	14	15	16	18	20	22	23	25	26	27	29	31	31	32	34	36
15								6	7	8	9	10	11	12	13	14	16	17	18	21	22	24	26	27	28	30	31	32	35	37	39	41
14							6	7	8	9	10	11	12	13	15	16	18	20	22	24	25	27	28	30	31	33	35	37	40	42	45	48
13						6	7	8	8	10	11	12	14	15	17	18	21	22	25	27	28	30	31	33	35	38	41	43	47	49	52	55
12						7	8	8	10	11	12	14	16	17	20	22	24	26	28	30	31	33	36	39	41	44	48	51	55	58	61	65
11					6	8	8	10	11	13	14	16	18	21	23	26	27	30	31	33	36	39	43	46	49	53	57	60	65	68	73	77
10				6	7	8	10	11	13	15	17	20	22	25	27	29	31	34	37	40	44	48	51	56	60	64	68	73	79	83	88	93
9			6	7	8	10	11	13	16	18	21	24	27	29	31	34	38	41	45	50	54	59	63	68	74	79	84	90	97	102	108	115
8			7	8	10	12	14	16	20	23	26	29	31	34	38	43	48	52	57	63	68	74	80	87	93	100	107	114	123	129	137	146
7		6	8	10	12	15	18	22	25	28	31	35	40	45	50	56	62	68	75	82	89	97	106	113	122	131	140	149	161	169	179	190
6	6	7	10	12	16	20	24	28	31	36	41	48	54	61	68	76	85	93	102	112	122	132	143	154	166	178	190	203	219	230	244	259
5	7	10	13	17	22	27	31	37	44	51	60	68	78	88	99	110	122	134	147	161	175	190	206	222	239	256	274	292	315	331	352	373
4	10	14	20	26	31	39	48	58	69	80	93	107	122	138	154	172	190	210	230	252	274	297	322	347	373	400	428	457	493	518		
3	15	24	31	41	54	68	84	102	121	143	165	190	216	244	273	304	337	372	408	446	486	527										
2	31	47	68	93	121	154	190	230	273	321	372	427	486	548																		
1	122	190	273	372	486	615																										

MEAN COEFFICIENT OF VARIABILITY: $\frac{\left(\frac{\sigma_1}{M_1} \times 100\right) + \left(\frac{\sigma_2}{M_2} \times 100\right)}{2}$

Necessary difference to give odds of 19 to 1 using the $\frac{\bar{x}}{\sigma} = 1.95$ value.

$$\frac{M_1 - M_2}{\sigma_d} = 1.95 \qquad \frac{12}{\sigma_d} = 1.95 \qquad \sigma_d = 6.15$$

$\sigma_d = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$ if $\sigma_1 = \sigma_2$ and $N_1 = N_2$ then $\sigma_d = \sqrt{\frac{2\sigma^2}{N}}$ or $N = \frac{2\sigma^2}{\sigma_d^2}$

$$N = \frac{2 \times 30^2}{6.15^2} \qquad N = 47.55$$

Check

Necessary difference (ND) to give odds of 19 to 1 with t value of 1.95996 ($P = .05$ and $n = \infty$).

$$ND = \sigma_d \times t \qquad \sigma_d = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} \qquad \therefore ND = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} \times t$$

$$ND = \sqrt{\frac{2 \times 30^2}{47.55}} \times t \qquad ND = \sqrt{37{\cdot}85} \times 1.95996 \qquad ND = 12.05$$

$$\text{Per cent difference } \frac{12.05}{300} \times 100 = 4.017$$

An accurate check is thus obtained when consideration is given to the fact that $\frac{\bar{x}}{\sigma} = 1.95$ and P at $n = \infty = .05$ are not exact opposites.

Our sincere thanks are due Mr. C. H. Schroeder and Mrs. H. B. Lawrence of the Larrowe Research Farm and to Mr. J. W. Hopkins of the National Research Council for helpful discussions.

RESUME

La signification des chiffres de détermination. S. Bird et H. S. Gutteridge, Service de l'Aviculture, Ferme expérimentale centrale, Ottawa.

Le tableau ici présenté montre le nombre d'individus qui est nécessaire dans chacun de deux groupes expérimentaux pour réduire à cinq pour cent (P = .05) la probabilité qu'une certaine différence soit produite par la chance seule. Il faut que le coefficient de variabilité, de même que la différence dont la démonstration est cherchée, soient connus. Par contre, admettant que l'on ait un nombre spécifique d'individus pour deux groupes expérimentaux, et une évaluation raisonnablement sûre du coefficient de variabilité, on peut aisément déterminer, d'après ce tableau, la différence nécessaire en pourcentage qui doit exister entre deux observations moyennes pour qu'on puisse établir, par des chances de 19 à 1, que cette différence est due au traitement expérimental dont ces groupes sont l'objet et non pas à la chance seule. Le tableau indique le nombre nécessaire d'individus laissés pour la comparaison à la fin d'une épreuve. Il faudra donc augmenter le nombre exigé au commencement, proportionnellement aux pertes qui peuvent se produire pendant l'essai. Les unités simples de ces lots devront nécessairement être tirés du même univers et devront, par conséquent, dans peut-être tous les cas, être du même sexe, car une réponse différente de sexe au traitement expérimental produirait une distribution bimodale ou oblique à laquelle les mesures ordinaires de variabilité ne pourraient être appliquées.

INFLUENCE OF RUST INJURY ON THE VIGOUR AND YIELD OF TIMOTHY[1]

J. N. Bird[2]

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[Received for publication March 23, 1934]

Among the factors which contribute to the successful adaptation of timothy in certain regions is the ability to resist a disease known as timothy rust, caused by *Puccinia graminis phlei-pratensis* (Eriks. & Henn.) S. & P.

Webber (*6*) and Piper (*4*) have regarded rust as "the most serious disease affecting timothy." Horsfall (*3*) has labelled it "a destructive disease," although he reviews a number of observations from different sources which reflect some diversity of opinion on the matter and suggest the need of further evidence.

Timothy Rust at Macdonald College

A rather striking demonstration of the destructiveness of the disease was afforded during the late summer of 1932, when seasonal or local conditions, or both, seemed to provide an extra favourable environment for the development of the disease.

A total of 116 strains, collected from widespread North American and European sources, had been transplanted to the timothy nursery as individual plants in June of that year. The plants were spaced 30 × 32 inches apart, and the strains consisted of single 2-row lots of 50 (in a few cases 1-row lots of 25) plants each, with a common "check" strain at 35-foot intervals throughout the test. This material had been handled in a uniform manner both before and after planting and developed in a normal manner until the rust appeared.

Although the rust infection was distributed among plants throughout the entire test, it appeared more general in certain areas.

No survey was made to determine if more than one species of rust was responsible for the injury. Attention was focussed on the intensity of infection, as indicated by the development of rust pustules on the leaves, and the influence of the parasite upon the apparent vigour of its host.

In order to obtain some measure of the differential reaction of strains and of plants within strains to the rust disease, it was decided that each individual plant should be graded according to the extent of infection and resultant injury, as indicated in the following scale:

Grades of Rust Injury, September, 1932

0 = plant apparently free from rust;
1 = plant with slight amount of rust injury but with no pustules visible;
2, 3, and 4 = plants showing an increasing intensity of infection and rust injury;
5 = plant almost dead as a result of rust injury.

The frequencies within these grades for a large number of strains may be found in Tables 1 and 2.

[1] Contribution from the Faculty of Agriculture of McGill University, Macdonald College, P.Q., Canada. Journal Series No. 39.

[2] Lecturer in Agronomy.

TABLE 1.—INFLUENCE OF RUST INJURY ON THE VIGOUR OF TIMOTHY. IMPROVED AND REGIONAL STRAINS

Designation of strain	Origin	Plants set out	Frequencies within grades of rust injury. Sept., 1932						Frequencies within grades of spring vigour. May, 1933					
			0	1	2	3	4	5	0	1	2	3	4	5
F.C. 11891	U.S.A.	50	23	19	4	3	1	—	0	2	10	25	13	—
F.C. 12454	U.S.A.	50	22	22	4	2	—	—	0	2	9	26	12	1
F.C. 12468	U.S.A.	50	25	24	1	—	—	—	0	0	2	27	21	—
Waldron	U.S.A.	50	8	19	9	11	2	1	0	8	16	20	6	—
F.C. 3937	U.S.A.	50	23	22	1	3	1	—	0	3	11	17	19	—
Check	U.S.A.	50	11	24	7	6	1	1	0	1	17	20	12	—
F.C. 12368	U.S.A.	50	21	20	5	2	0	2	0	3	10	18	19	—
F.C. 12365	U.S.A.	50	19	21	8	1	1	—	0	4	9	22	15	—
F.C. 11791	U.S.A.	50	27	18	2	1	2	—	0	3	5	26	16	—
Cornell No. 1777	U.S.A.	50	8	20	8	7	7	—	1	4	16	26	3	—
Cornell No. 4059	U.S.A.	50	6	14	18	9	3	—	1	7	20	16	6	—
Check	—	50	8	20	8	7	7	—	1	4	16	26	3	—
Φtofte	Denmark	50	35	7	0	5	2	1	0	4	6	25	15	—
Kampe I	Sweden	50	13	6	10	7	11	3	2	14	18	13	3	—
Kampe II	Sweden	50	18	11	3	4	10	4	1	11	11	15	12	—
Weihenstephan	Germany	50	36	7	2	2	2	1	0	4	7	26	13	—
Schivarzwald	Germany	50	8	11	9	11	9	2	0	12	23	11	4	—
Lischower	Germany	50	32	12	2	2	2	—	0	0	15	27	8	—
Check	—	50	22	14	7	5	1	1	0	3	19	16	12	—
Moravian	Cz'vakia	50	15	15	7	4	8	1	2	12	6	26	4	—
Lappi	Finland	50	5	3	8	9	21	4	7	20	13	8	2	—
P-586	Finland	50	16	8	8	13	5	—	0	14	17	12	7	—
Check	—	50	22	12	4	8	4	—	3	5	12	21	9	—
Scottish	Scotland	50	11	4	7	13	14	1	3	15	16	14	2	—
S. 51	Wales	50	38	6	3	2	1	—	0	0	10	24	16	—
S. 48	Wales	50	37	6	3	4	—	—	0	0	8	32	9	1
Grindstad	Norway	50	3	6	9	16	16	—	0	20	19	7	4	—
Biskopsbole	Finland	50	3	6	6	16	17	2	1	12	29	6	2	—
Haukila	Finland	50	8	5	11	8	17	1	0	7	27	12	4	—
Check	—	50	17	8	10	11	4	—	0	4	17	18	11	—
Ekero	Finland	50	8	6	3	12	15	6	1	11	24	9	5	—
Gloria	Sweden	50	29	5	4	7	5	—	0	3	10	16	21	—
Bore	Sweden	50	3	9	12	19	6	1	2	5	25	14	4	—
Bottnia	Sweden	50	4	3	6	12	22	3	2	13	23	6	5	1
Check	—	50	15	11	3	8	12	1	0	6	15	13	16	—
All strains	—	1450	504	335	173	205	200	33	23	213	415	526	270	3
All checks	—	300	95	89	39	45	29	3	4	23	96	114	63	0

Table 2.—Influence of Rust Injury on Yield of Timothy

IMPROVED AND REGIONAL STRAINS

Designation of strain	Origin	Frequencies within grades of rust injury. Sept., 1932							Total green yields in ounces within grades of rust injury. 1933							Average green yields per plant in ounces within grades of rust injury. 1933						
		0	1	2	3	4	5	Total	0	1	2	3	4	5	Total	0	1	2	3	4	5	Average
508	M.C.	19	27	2	0	2	—	50	385	357	18	—	3	—	763	20.3	13.2	9.0	—	1.5	—	15.3
603	M.C.	16	30	2	1	1	—	50	286	550	22	4	1	—	863	17.9	11.9	11.0	4.0	1.0	—	17.3
Check	U.S.A.	22	18	6	2	2	—	50	400	267	76	13	8	—	764	18.2	14.8	12.7	6.5	4.0	—	15.3
710	M.C.	25	21	2	1	1	—	50	508	401	36	6	6	—	957	20.3	19.1	18.0	6.0	6.0	—	19.1
712	M.C.	31	11	4	2	1	1	50	676	211	45	14	3	1	950	21.8	19.2	11.2	7.0	3.0	1.0	19.0
Check	—	25	14	6	4	1	—	50	469	204	45	16	4	—	738	18.8	14.6	7.5	4.0	4.0	—	14.8
805	M.C.	26	21	0	1	2	—	50	589	430	—	9	10	—	1038	22.6	20.5	—	9.0	5.0	—	20.8
819	M.C.	24	19	3	1	2	1	50	587	409	46	11	9	1	1063	24.4	21.5	15.3	11.0	4.5	1.0	21.3
Check	—	18	20	6	4	2	—	50	429	345	41	28	7	—	850	23.8	17.2	6.8	7.0	3.5	—	17.0
F.C. 12468	U.S.A.	25	24	1	—	—	—	50	426	352	6	—	—	—	784	17.0	14.7	6.0	—	—	—	15.7
F.C. 3937	U.S.A.	23	22	1	3	1	—	50	386	260	3	21	2	—	672	16.8	11.8	3.0	7.0	2.0	—	13.4
Check	—	11	24	7	6	1	1	50	228	437	65	34	2	1	767	20.7	18.2	9.3	5.7	2.0	1.0	15.3
F.C. 11791	U.S.A.	27	18	2	1	2	—	50	479	283	10	3	4	—	779	17.7	15.7	5.0	3.0	2.0	—	15.6
Cornell No. 1777	U.S.A.	8	20	8	7	7	—	50	110	186	63	41	15	—	415	13.8	9.3	7.9	5.9	2.1	—	8.3
Cornell No. 4059	U.S.A.	6	14	18	9	3	—	50	94	166	85	31	4	—	380	15.7	11.8	4.7	3.4	1.3	—	7.6
Check	—	8	20	8	7	7	—	50	110	186	63	41	15	—	415	13.8	9.3	7.9	5.9	2.1	—	8.3
Ftofte	Denmark	35	7	0	5	2	1	50	638	101	—	19	4	1	763	18.2	14.4	—	3.8	2.0	1.0	15.3
Weihenstephan	Germany	36	7	2	2	2	1	50	567	96	12	6	6	2	689	15.7	13.7	6.0	3.0	3.0	2.0	13.8
Check	—	22	14	7	5	1	1	50	332	174	32	14	3	1	556	15.1	12.4	4.6	2.8	3.0	1.0	11.1
Lappi	Finland	5	3	8	9	21	4	50	80	40	33	21	21	0	195	16.0	13.3	4.1	2.3	1.0	0.0	3.9
Check	—	22	12	4	8	4	—	50	371	128	13	26	6	—	544	16.9	10.7	3.2	3.2	1.5	—	10.9
S. 51	Wales	38	6	3	2	1	—	50	575	72	26	9	4	—	686	15.1	12.0	8.7	4.5	4.0	—	13.7
S. 48	Wales	37	6	3	4	—	—	50	596	88	30	44	—	—	758	16.1	14.7	10.0	11.0	—	—	15.2
Check	—	17	8	10	11	4	—	50	317	63	81	47	9	—	517	18.6	7.9	8.1	4.3	2.2	—	10.3
Gloria	Sweden	29	5	4	7	5	—	50	557	91	32	47	12	—	739	19.2	18.2	8.0	6.7	2.4	—	14.8
Bottnia	Sweden	4	3	6	12	22	3	50	107	47	49	64	65	6	338	26.7	15.7	8.1	5.3	2.9	2.0	6.8
Check	—	15	11	3	8	12	1	50	285	250	31	42	34	3	645	19 0	22.7	10.3	5.2	2.8	3.0	12.9

SINGLE-PLANT STRAINS FROM BRITISH ISLES AND NORTHERN EUROPE

Designation of strain	Origin	Frequencies within grades of rust injury. Sept., 1932							Total green yields in ounces within grades of rust injury. 1933							Average green yields per plant in ounces within grades of rust injury. 1933						
		0	1	2	3	4	5	Total	0	1	2	3	4	5	Total	0	1	2	3	4	5	Average
1002		22	0	0	1	2	—	25	629	—	—	10	8	—	647	28.6	—	—	10.0	4.0	—	25.9
Check		12	3	2	4	4	—	25	227	47	24	15	5	—	318	18.9	15.7	12.0	3.7	1.2	—	12.7
1015		1	1	2	4	15	2	25	24	18	7	7	16	1	73	24.0	18.0	3.5	1.7	1.0	0.5	2.9
Check		9	7	3	4	2	—	25	187	78	14	32	6	—	317	20.8	11.1	4.7	8.0	3.0	—	12.7
1022		9	8	6	2	—	—	25	158	129	39	12	—	—	338	17.5	16.1	6.5	6.0	—	—	13.5
1028		11	5	4	1	4	—	25	246	58	39	14	24	—	381	22.4	11.6	9.7	14.0	6.0	—	15.2
Check		6	6	4	6	3	—	25	112	49	33	28	5	—	227	18.7	8.1	8.2	4.7	1.7	—	9.1
1035		19	4	0	2	—	—	25	201	36	—	7	—	—	244	10.6	9.0	—	3.5	—	—	9.8
1036		—	3	3	10	9	—	25	—	26	3	7	5	—	41	—	8.7	1.0	0.7	0.5	—	1.6
1037		24	0	0	0	1	—	25	427	—	—	—	7	—	434	17.8	—	—	—	7.0	—	17.4
1038		16	4	0	2	3	—	25	255	55	—	22	11	—	343	15.9	13.7	—	11.0	3.7	—	13.7
Check		11	2	1	8	3	—	25	153	10	12	20	8	—	203	13.9	5.0	12.0	2.5	2.7	—	8.1
1041		15	6	0	3	1	—	25	205	67	—	5	6	—	283	13.7	11.1	—	1.7	6.0	—	11.3
Check		9	5	5	3	3	—	25	131	45	42	15	7	—	240	14.5	9.0	8.4	5.0	2.3	—	9.6
1053		20	2	2	—	—	—	24	370	27	30	—	—	—	427	18.5	13.5	15.0	—	—	—	17.8
Check		12	5	5	1	2	—	25	146	55	45	2	8	—	256	12.2	11.0	9.0	2.0	4.0	—	10.2
All strains		551	297	86	92	110	13	1149	10161	4556	634	434	246	12	16043	—	—	—	—	—	—	—
Average weight of plants		—	—	—	—	—	—	—	18.4	15.3	7.4	4.7	2.2	0.9	—	18.7	14.3	8.2	5.9	3.1	1.1	13.8
All checks		220	168	77	81	51	3	600	3897	2338	617	373	127	5	7357	—	—	—	—	—	—	—
Average weight of plants		—	—	—	—	—	—	—	17.7	13.9	8.0	4.6	2.5	1.7	—	17.6	12.5	8.3	4.7	2.7	1.7	11.9

Influence of Rust Injury on Spring Vigour

The influence of rust injury incurred during the late summer of 1932 was clearly evident among plants in the nursery in the following spring. Differences in the vigour of strains, and of individuals within strains, appeared quite striking and suggested a close correlation with the rust injury of the previous year. In order to test this correlation, individual plants throughout the entire test were graded according to the following scale:

Grades of Spring Vigour, May, 1933

0 = plant dead;
1 = plant showing only faint indications of life;
2, 3, 4 and 5 = plants showing increasing degrees of vigour.

The frequencies within these grades for the plants of 29 strains, grown together in one section of the nursery, are presented in Table 1, along with the corresponding frequencies within rust grades obtained in September of the previous year. Similar data have been presented for the nearest check, which follows each strain or group of strains throughout the table.

A survey of the frequencies presented in this table will reveal some outstanding differences between strains in regard both to rust injury and to spring vigour. High frequencies in the lower grades of rust injury are associated with low frequencies in the lower grades of spring vigour, and vice versa. Moreover, this relationship is apparent whether strains are considered singly or combined.

Influence of Rust Injury on Yield

During the early summer of 1933, differences in vigour, far from becoming obliterated by the season's growth, became much more intensified (Figure 1). On this account it seemed worth while to obtain green yields from individual plants immediately following bloom in order to arrive at a more exact appreciation of the influence of the different grades of rust injury than a grading for vigour allowed.

The frequencies within various grades of rust injury, along with corresponding total green yields, as well as the corresponding average yield per plant within these grades for 28 representative strains, are presented in Table 2. Similar data for the nearest check follow each strain or group of strains. From these results, the average green yields per plant within each grade of rust injury have been calculated, both for the 28 strains and for the common "check" strain. These averages are expressed graphically in Figures 2 and 3. For increasing grades of rust injury, viz., 0, 1, 2, 3, 4, and 5, the corresponding average green yields of plants for 28 strains were 18.4, 15.3, 7.4, 4.7, 2.2 and 0.9 ounces respectively and for the common "check" strain 17.7, 13.9, 8.0, 4.6, 2.5 and 1.7 ounces respectively. The average green yields of plants within the various grades of rust injury in the case of the common "check" strain did not differ greatly from those obtained when 28 representative strains were averaged.

A statistical measure of the significance of rust injury as a factor influencing the yield of timothy may be obtained from a comparison of the variance (*2*) between and within grades of rust injury for the 28 strains as shown in Table 3.

FIGURE 1. Influence of rust injury on yield of timothy; differential injury between and within three strains.

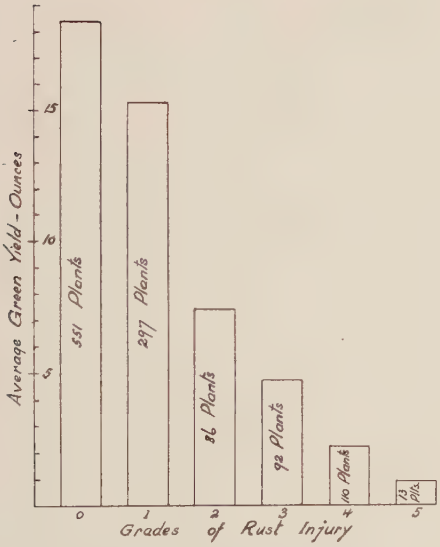

FIGURE 2. Average green yields per plant in ounces within grades of rust injury for 28 strains — 1149 plants.

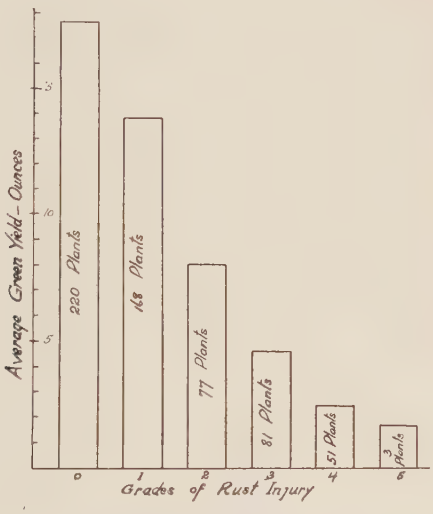

FIGURE 3. Average green yields per plant in ounces within grades of rust injury for "Check" strain—600 plants.

TABLE 3.—VARIANCE OF YIELDS BETWEEN AND WITHIN RUST GRADES

—	Sum of squares	D.F.	Mean square	$\frac{1}{2}$ Log$_e$ (M.S.)	z value	z value for 1% point
Strains: Total (28)						
Plants: 1149						
Mean yield: 13.8 ozs.						
Between grades:	40,536.34	5	8,107.26	3.349	2.8702	0.552
Within grades:	29,797.05	1143	26.07	0.479		

A comparison of the z value with the corresponding 1% point in the above data reveals a significant difference between the yields obtained in the six grades of rust injury.

Significant differences are also obtained when high, medium, and low-yielding strains are selected and given the same statistical treatment. (Table 4).

TABLE 4.—VARIANCE OF YIELDS BETWEEN AND WITHIN RUST GRADES

—	Sum of squares	D.F.	Mean square	$\frac{1}{2}$ Log$_e$ (M.S.)	z value	*z value* for 1% point
High:						
Strain: M.C. No. 710						
Plants: 50						
Mean yield: 19.1 ozs.						
Between grades:	382.77	4	95.69	1.129	0.979	0.647
Within grades:	607.26	45	13.49	0.150		
Medium:						
Strain: Cornell 4059						
Plants: 49						
Mean yield: 7.7 ozs.						
Between grades:	1031.12	4	257.78	1.625	1.346	0.647
Within grades:	767.94	44	17.45	0.278		
Low:						
Strain: Lappi						
Plants: 43						
Mean yield: 4.5 ozs.						
Between grades:	1129.66	4	282.41	1.670	1.631	0.695
Within grades:	411.06	38	10.82	0.039		

The z value in each case exceeds the 1% point by a considerable margin.

A study of the average green yields per plant for different strains, as presented in the last column of Table 2, reveals some rather outstanding differences in yield per plant. On the other hand, when the average yields of plants classified according to rust injury for these same strains are compared no such differences between strains are apparent. This would suggest that, under the conditions of this study, rust injury was a very important factor influencing the yielding ability of these strains.

Discussion

There are a number of reasons why one might expect to find in the literature a diversity of opinion regarding the economic importance of timothy rust. Seasonal or local conditions, or both, may either favour or retard the development of the disease. The rust attack may arrive too late in the season to influence the hay crop of that year, but may seriously affect the seed crop as in Wales (*5*), or the influence of the rust injury may be carried over and affect the hay crop of the following year and may even curtail the longevity of the crop, as Webber (*6*) has pointed out. Consideration must also be given to the differential reaction of timothy strains to rust attack. Plant breeders such as Webber (*6*), Witte (*7*), Clarke (*1*) and others have demonstrated the possibility of isolating disease-resistant strains. Moreover, in regions where timothy rust has frequently been destructive, it is conceivable that natural selection may have eliminated a large proportion of the more susceptible plants from the regional population, with a consequent improvement in disease resistance. There is also the possibility that different species of fungi or different physiologic forms may be responsible for timothy rust in different places and therefore cause differences of opinion as to the importance of the disease.

One of the most striking features of strain reaction in this test was the high susceptibility of strains from Scandinavian Europe. The improved strains—Gloria, from the Svalof station, and Ötofte from the Ötoftegaard station—were, however, outstanding in their resistance to the disease, when compared with ten other Scandinavian strains included in the test. Similar observations have been made by Stapledon (*5*) in respect to the rust of different species of grasses.

Generally speaking, the large majority of improved strains included in this test showed marked resistance and gave a clear-cut demonstration of the result of careful selection for rust-resistance at the various stations where they were produced.

Although strains differed greatly in their reaction to the disease, the reaction of individual plants within strains also varied greatly. No strains were found to be 100% free from the disease. Even in those strains with lowest injury, individuals were found showing, in some cases slight, and in others definite, indications of rust injury. Likewise, in the most susceptible strains, exceptional plants were found, which were quite vigorous in appearance and either free from, or showing slight indications of, rust injury. These latter plants were, in many cases, surrounded by individuals showing abundant infection and severe injury. In a large proportion of the strains, there was a regular gradation of rust injury presented by individuals within the strain, varying from plants showing no trace of the disease to others almost dead as a result of it. To account for such plant-to-plant variation within strains, the possibility of irregular infection could not be ruled out, but it seemed more likely that the variation was due to a differential resistance of individuals within the strain to rust attack.

In devising a scale for the gradation of plants according to rust injury, it appeared necessary to consider not only intensity of infection, as indicated by the development of pustules upon the leaves, but also the influence of

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the parasite upon the vigour of its host. One might have expected that, under apparently increasing amounts of infection, plants would have shown increasing degrees of injury, but this was not always the case. Certain plants seemed to withstand a given amount of infection, as judged by pustule development, with much less injury than others, due perhaps, to genotypic differences between the individual plants.

While such decreases in vigour and yield due to rust injury, obtained from a study of individual plants, are not directly applicable to field conditions, where plants grow matted together in a sod, they are nevertheless indicative of the serious nature of the disease. Furthermore, the differential injury of strains, and of individuals within strains, by this disease would appear an important cause of variability in breeding material and should therefore be given consideration, whenever comparisons are made either between or within strains.

It should not be assumed that such injury to timothy as resulted from the rust epidemic of 1932 would prevail in every season. The severity of the rust attack in this particular year was of an exceptional nature, as has been pointed out above. The results presented are therefore not indicative of average conditions; otherwise, the differences between yields of plants classified according to rust grade might have been considerably less significant. For the establishment of differences in rust-resistance of strains, it would seem necessary that environmental conditions should strongly favour the development of the disease. In nature, such environmental conditions are largely beyond the control of the plant breeder, and the only course for him to follow, under such circumstances, is to await an epidemic of the disease. On the other hand, controlled infection of plants in the greenhouse would seem to offer some promise in the study of strain reaction.

Summary

Results are presented from a study of the influence of rust injury on the vigour and yield of timothy in the following year.

The study was based upon individual plants within 116 local and foreign strains. These plants were graded according to rust injury during an epidemic of timothy rust which commenced in the late summer of 1932. The same plants were graded according to spring vigour in May of the following year. Individual plant yields were obtained for a number of representative strains by taking green yields of plants immediately following bloom.

A comparison of the yield of these individual plants within different grades of rust injury in 28 strains indicated the importance of the disease as a cause of differential vigour and yield within and between strains.

Acknowledgment

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L'effet de la rouille sur la vigueur et le rendement du mil. J. N. Bird, Collège Macdonald, P.Q.

Sous ce titre, sont présentés les résultats d'une étude de l'effet de la rouille sur la vigueur et le rendement de la fléole des près (mil) l'année suivante (1933). L'étude était basée sur des plantes séparées, appartenant à 116 espèces locales et étrangères. Ces plantes ont été classées d'après les dégâts causés par la rouille au cours d'une épidémie de rouille de la fléole qui a commencé à sévir vers la fin de l'été de 1932, et ont été reclassées une deuxième fois d'après la vigueur qu'elles avaient en mai de l'année suivante. On s'est procuré les rendements individuels par plante d'un certain nombre d'espèces représentatives en prenant les rendements en vert des plantes immédiatement après la floraison. Une comparaison du rendement de ces différentes plantes pour différents degrés de dégâts causés par la rouille dans 28 espèces a fait ressortir l'importance de la maladie comme cause des différences de vigueur et de rendement dans les espèces et entre les expèces.

THE INHIBITION OF THE GROWTH OF FUNGI BY CHEMICALS[1]

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Although there exists considerable information on the concentrations of various chemicals that are lethal to fungi comparatively little information is available upon the concentrations that inhibit the growth of fungi, and these two critical concentrations may not be related. At concentrations lethal to fungi many chemicals are quite toxic to the host plant, while at a concentration that inhibits fungal growth the chemical may possess little if any toxicity toward the host plant. These investigations have been conducted in the hope of discovering solutions that would be absorbed by seed in sufficient quantities to exert an immunizing effect during the seedling stage of their growth. There are many plants that appear to be parasitized by fungi during the seedling stage only. Dessy (*1*) determined the inhibitory effect of 51 colouring agents and 24 metallic salts on the growth of *Penicillium* spp. He found active inhibition of growth by brilliant green, methyl violet, malachite green, alizarin blue, among the dyes and by mercury cyanide, mercuric chloride, cadmium nitrate and aluminium sulphate among the salts. In a later publication (*2*) Dessy investigated the effect of these compounds on *Mucor* spp. and found that the inhibitory effect was much less marked than for the *Penicillium* spp.

There have been no extensive investigations of the inhibitory effect of chemicals on the growth of *Fusarium* spp. Reynolds (*4*) reports that a minimum concentration of 0.3 molar of potassium cyanide prevented the growth of *F. lini bolley*. Houben and Wollenweber (*3*) found that concentrations of 0.005% to 0.01% of hexylresorcinol inhibited the growth of *F. aurantiacum* while *F. lini* required concentrations of 0.01% to 0.02%. Wollenweber also reports (*5*) that a concentration of 0.03% chinosol inhibits the growth of *F. lini*.

Determination of the Inhibition Concentrations

Experimental.—The nutrient medium used for this work was of the following composition:—

Na_2HPO_4	0.4 gm.	Sucrose	40.0 gm.
KNO_3	0.4 gm.	Water	1000.0 cc.
$MgSO_4$	0.4 gm.		

This medium was pipetted in 10 cc. amounts into test tubes and sterilized for 15 minutes at 15 lbs. pressure. Solutions of the chemical under investigation were made up at twice the concentration desired, pipetted in 10 cc. amounts into test tubes, and sterilized.

The following procedure was adopted: one test tube each of the medium and the chemical solution were poured into a petri dish and the mixture inoculated with a piece of fresh living mycelium of the fungus under investigation. The petri dishes were then incubated at 25° C. and after

[1] Contribution No. 397 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Ont.

7 days those concentrations of the chemical which completely prevented growth of the fungus were noted.

The inhibition concentrations towards four *Fusarium* spp. were investigated, namely *F. culmorum* (W. G. Sm.) Sacc., *F. moniliforme* Sheldon, *F. solani* (Mart.) App. et Wr., and *F. orthoceras* App. et Wr., representing the sections Discolor, Moniliforme, Martiella, and Elegans respectively. Table 1 shows the concentrations of chemicals which inhibited the growth of these *Fusarium* spp. under these experimental conditions, while Table 2 shows the chemicals which do not inhibit growth up to concentrations of 0.1 M. The accuracy of the inhibition constants is within 10% of the recorded values.

TABLE 1.—THE INHIBITION CONSTANTS OF CHEMICALS TOWARD *Fusarium* SPP. EXPRESSED AS MOLAR SOLUTIONS AND PER CENT CONCENTRATIONS

Chemical	Fusarium culmorum	Fusarium moniliforme	Fusarium solani	Fusarium orthoceras.
Potassium dichromate	0.0003 M	0.0007 M	0.0007 M	0.0003 M
Phenol	0.005 M	0.001 M	0.0007 M	0.0007 M
Mercuric chloride	0.001 M	0.0006 M	0.0008 M	0.0005 M
Cresol	0.001 M	0.001 M	0.001 M	0.001 M
Cheshunt compound ($CuSO_4$ 2 parts $(NH_4)_2CO_3$ 9 parts, molarity as copper sulphate	0.001 M	0.001 M	0.001 M	0.001 M
Mercurous sulphate	Saturated solution (approx. 0.001 M)			
Sodium bisulphite	0.007 M	0.007 M	0.007 M	0.007 M
Guaicol	0.007 M	0.007 M	0.008 M	0.007 M
Molybdic acid	Saturated solution (approx. 0.01 M)			
Lead chloride	Saturated solution (approx. 0.01 M)			
Zinc sulphate	0.01 M	0.02 M	0.06 M	0.01 M
Resorcinol	0.1 M	0.1 M	0.1 M	0.1 M
Malachite Green	0.001 %	0.0006 %	0.001 %	0.0006 %
Chinosol	0.006 %	0.01 %	0.006 %	0.006 %
Methylene Blue	0.05 %	0.05 %	0.05 %	0.05 %
Magenta	0.05 %	0.05 %	0.05 %	0.1 %
Indine Blue	0.1 %	0.1 %	0.1 %	0.1 %

TABLE 2.—CHEMICALS WHICH DO NOT INHIBIT THE GROWTH OF *Fusarium* SPP. UP TO CONCENTRATIONS OF 0.1 M (APPROXIMATELY 0.1 %)

Inorganic chemicals	Organic chemicals	Inorganic chemicals	Organic chemicals
Potassium iodate	Picric acid	Potassium thiocyanate	Aniline Blue
bromate	Benzoic acid	ferricyanide	Fluorescin
chlorate	Amyl acetate	ferrocyanide	Nigrosine
iodide	Auramine	permanganate[1]	
bromide	Rhodamine	Ferric chloride[2]	
chloride	Fuchsin	Sodium tartrate	

[1] The non-inhibiting effect of potassium permanganate was due to its reaction with the media resulting in its being reduced to manganese dioxide.

[2] The ferric chloride was almost completely converted to the oxide and as such did not show any inhibiting effect.

TABLE 3.—THE INHIBITION CONSTANTS OF CHEMICALS TOWARDS *Fusarium*, *Rhizoctonia* AND *Pythium*, EXPRESSED AS MOLAR SOLUTIONS AND PERCENT CONCENTRATIONS.

Chemical	*F. culmorum*		*Pythium*		*Rhizoctonia*	
	Growth	No growth	Growth	No growth	Growth	No growth
Copper sulphate	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Copper nitrate	0.001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.0001 M
Copper acetate	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Mercuric chloride	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Mercuric cyanide	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Silver nitrate	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Potassium dichromate	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Phenol	0.0001 M	0.001 M	0.0001 M	0.001 M	0.0001 M	0.001 M
Guaicol	0.001 M	0.01 M	0.001 M	0.01 M	0.001 M	0.01 M
Cresol	0.001 M	0.01 M	0.001 M	0.01 M	0.001 M	0.01 M
Potassium cyanide	0.001 M	0.01 M	0.001 M	0.01 M	0.001 M	0.01 M
Tannic acid	0.001 M	0.01 M	0.001 M	0.01 M	0.001 M	0.01 M
Barium chloride	0.01 M	0.1 M	0.001 M	0.01 M	0.01 M	0.1 M
Malachite green	0.0001 %	0.001 %	0.0001 %	0.001 %	0.0001 %	0.001 %

TABLE 4.—THE EFFECT OF CHEMICALS ON THE GROWTH OF WHEAT SEEDLINGS AS SHOWN BY THE HEIGHT OF THE SEEDLINGS

Chemical	Concentration	Height in cm.	Chemical	Concentration	Height in cm.
Check		16.0	Chinosol	0.1 %	12.0
				0.01 %	14.0
Copper acetate	0.01 M	4.0			
	0.001 M	14.0	Mercurous sulphate	Sat. soln.	15.0
Copper sulphate	0.01 M	4.5	Lead chloride	Sat. soln.	14.0
	0.001 M	13.5			
	0.0001 M	16.5	Zinc sulphate	0.1 M	7.5
Cheshunt compound	0.01 M	3.5	Barium chloride	0.1 M	5.5
	0.001 M	13.0			
			Guaicol	0.01 M	8.0
Copper nitrate	0.01 M	4.5			
	0.001 M	12.0	Molybdic acid	Sat. soln.	8.5
	0.0001 M	15.5			
			Silver nitrate	0.1 M	4.5
Potassium dichromate				0.01 M	8.0
	0.01 M	4.5		0.001 M	7.5
	0.001 M	10.5			
			Mercuric cyanide	0.1 M	Killed
Potassium cyanide	0.1 M	3.5		0.01 M	Killed
	0.01 M	13.4		0.001 M	8.5
Cresol	0.1 M	10.0	Mercuric chloride	0.1 M	Killed
				0.01 M	5.5
Phenol	0.1 M	7.0		0.001 M	7.5
	0.01 M	14.0			
			Resorcinol	0.1 M	Killed
Malachite green	0.1 %	7.5			
	0.01 %	10.5			
	0.001 %	11.0			

TABLE 5.—THE RELATIVE CONCENTRATIONS OF CHEMICALS INHIBITING THE GROWTH OF FUNGI AND WHEAT

Chemical	Minimum concentration inhibiting fungi	Maximum concentration not inhibiting wheat	Ratio
Phenol	0.001 M	0.01 M	10
Cresol	0.01 M	0.1 M	10
Chinosol	0.01 %	0.1 %	10
Malachite green	0.001 %	0.1 %	10
Copper sulphate	0.001 M	0.001 M	1
Copper nitrate	0.001 M	0.001 M	1
Copper acetate	0.001 M	0.001 M	1
Cheshunt compound	0.001 M	0.001 M	1
Potassium dichromate	0.001 M	0.001 M	1
Potassium cyanide	0.01 M	0.01 M	1
Mercurous sulphate	Sat. soln.	Sat. soln. does not inhibit	1
Lead chloride	Sat. soln.	Sat. soln. does not inhibit	1
Molybdic acid	Sat. soln.	Sat. soln. inhibits	Below 1
Zinc sulphate	0.1 M	Below 0.1 M	Below 1
Barium chloride	0.1 M	Below 0.1 M	Below 1
Silver nitrate	0.001 M	Below 0.001 M	Below 1
Mercuric chloride	0.001 M	Below 0.001 M	Below 1
Mercuric cyanide	0.001 M	Below 0.001 M	Below 1
Resorcinol	0.1 M	Below 0.1 M	Below 1
Guaicol	0.01 M	Below 0.01 M	Below 1

It will be seen from Table 1 that the inhibition concentrations were practically the same for the four species of *Fusarium*. Hence, in later investigations only one species, *F. culmorum*, was used and this species of *Fusarium* was compared with species of other genera namely, *Rhizoctonia solani* Kühn and *Pythium ultimum* Trow. Those chemicals that materially inhibited the growth of the *Fusarium* spp. and other chemicals were studied in the later investigation. Dilutions of one to ten only were made, hence the inhibition concentrations may be anywhere between the two values recorded in Table 3.

THE INHIBITION OF GROWTH OF WHEAT SEEDLINGS

In order to determine the possible utility of the more effective chemicals as a soil treatment against infection it was necessary to find the effect of the chemicals on the growth of seedlings. Wheat was chosen as a test crop since it is a fairly rapid grower and easily handled.

Wheat was germinated by placing it in the incubator between wet blotting paper for 36 hours. Lots of twenty well germinated seeds were then counted and placed on wire gauze over an open half petri dish. Hoagland's plant nutrient solution was poured into the dish and the seedlings allowed to grow for 7 days at which time they were about 4 cm. high. At this time fresh Hoagland's solution containing the chemicals under investigation was added and the plants were grown for another seven days after which the growth was determined by measuring the length of the plant. The data are presented in Table 4.

Discussion

The important factor in work of this type is not so much to obtain a chemical which at low concentrations is inhibitory to fungal growth as one that while inhibitory to the fungous is non-inhibitory to plant growth at concentrations considerably higher than it is inhibitory to fungal growth. That is, the ratio of "dosis tolerata" to "dosis toxica" should be as high as possible. Reference to Table 4, shows that with the exception of copper sulphate at a concentration of 0.001 molar and copper nitrate at the same concentration, none of the chemicals used in this investigation was without some effect on the plants. The first eleven chemicals in Table 4, however, while retarding growth to some extent did not cause serious injury at concentrations above that required to inhibit the growth of the fungus.

Table 5, shows the minimum concentration of the various chemicals which inhibited fungal growth and the maximum concentrations which allowed the wheat to grow to a height of at least 10 cm. The final column shows the ratio of "dosis tolerata" to "dosis toxica." The ratio was greater than one only in four cases, namely, phenol, cresol, chinosol, and malachite green. In the cases of copper sulphate, acetate and nitrate, Cheshunt compound, potassium cyanide, mercurous sulphate, lead chloride and potassium dichromate, the ratios were one, while the other chemicals gave ratios below one indicating that the concentration required to inhibit the fungus is greater than the maximum concentration tolerated by the wheat.

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RESUME

L'effet de certains ingrédients chimiques sur la croissance des cryptogames. F. L. Munro et W. Newton, Laboratoire fédéral de phytopathologie, Saanichton, C.-B.

L'effet d'un certain nombre de concentrations d'ingrédients chimiques sur des espèces de *Fusarium*, de *Pythium* et de *Rhizoctonie* et l'effet de ces concentrations et d'autres sur la croissance des plantules de blé ont été déterminés. La proportion entre les concentrations maxima tolérées par les plantules de blé et les concentrations minima qui arrêtent la croissance des champignons, était de dix pour le phénol, le crésol, le chinosol et le vert malachite, et d'un pour le sulfate de cuivre, le nitrate de cuivre, l'acétate de cuivre, le composé Cheshunt, le dichromate de potassium, le cyanure de potassium et le chlorure de plomb. Tous les autres ingrédients chimiques à l'essai ont donné une proportion inférieure à un. Ceci porte à croire que seuls les ingrédients chimiques qui paraissent sur cette liste peuvent être utiles dans la lutte contre les maladies des plantes.

THE EFFICIENCY OF USE OF FARM POWER[1]

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[Received for publication February 22, 1934]

The cost of farming operations involving the use of power is materially influenced by the efficiency with which the power is used. In other words, the ratio of power actually used to the potentialities of the power unit is an important cost factor. In ordinary field operations the power used must have some margin over the usual draft requirement of the implement being operated, but the amount of surplus cannot be easily determined. With horses, lack of a surplus of power is not immediately evident, and there are good reasons for supposing that many horses are overworked for considerable periods. With tractors, lack of a surplus results almost immediately in stalling of the outfit; hence tractors are almost certain to be operating loads below their maximum capacity.

To determine the extent of such overloading or underloading, a series of drawbar tests (45 in all) were made in the summer and fall of 1931. The season was hot and unusually dry, thus resulting in higher draft for plows and lower draft for such implements as combines. To obtain the necessary data, it was decided to make a series of draft tests under actual farm conditions. An hydraulic dynamometer, steel tape, and stop watch were loaded in an automobile, and by driving out into the surrounding district farmers were found at work. Each farmer whose outfit was tested was asked to continue his operations without making any adjustments, and as the routine of the test had been well worked out previously, the loss of time to the farmer was less than five minutes per test and in many cases did not exceed two minutes. This was an important factor in securing the voluntary co-operation of the farmer. In addition the farmer was promised the results of the test by mail, and in this way his correct name and address were secured. This plan succeeded excellently, only one refusal being received.

The tests made by this method naturally cover a broad group of conditions. The tillage implements studied were all in the Red River valley within a radius of 30 miles of Winnipeg. The combines tested were all within a 20 mile radius of Portage la Prairie.

Type of outfit studied.—The tests made included 10 horse outfits and 35 tractor outfits. Plows, discs and cultivators were the implements being hauled by horses, while the tractor loads comprised plows, disc tillers, cultivators and 12 combines. The size of outfits varied from 3 horse to 8 horse, and the tractors varied in the maximum Draw Bar Horse Power from 8.25 to 33.2 h.p.

Results of the tests.—The graph (Plate I) gives the results of the various drawbar tests made. In this graph the heavy vertical bars represent the average h.p. developed by each outfit. Reading from the left, the first

[1] The Canadian Pioneer Problems Committee commissioned the authors to investigate the efficiency with which Manitoba farmers were utilizing the various types of power units. The discussion which follows is summarized from the report sent to the Committee and is given with their authorization.
[2] Specialist in Agricultural Engineering and Professor of Agricultural Engineering respectively.

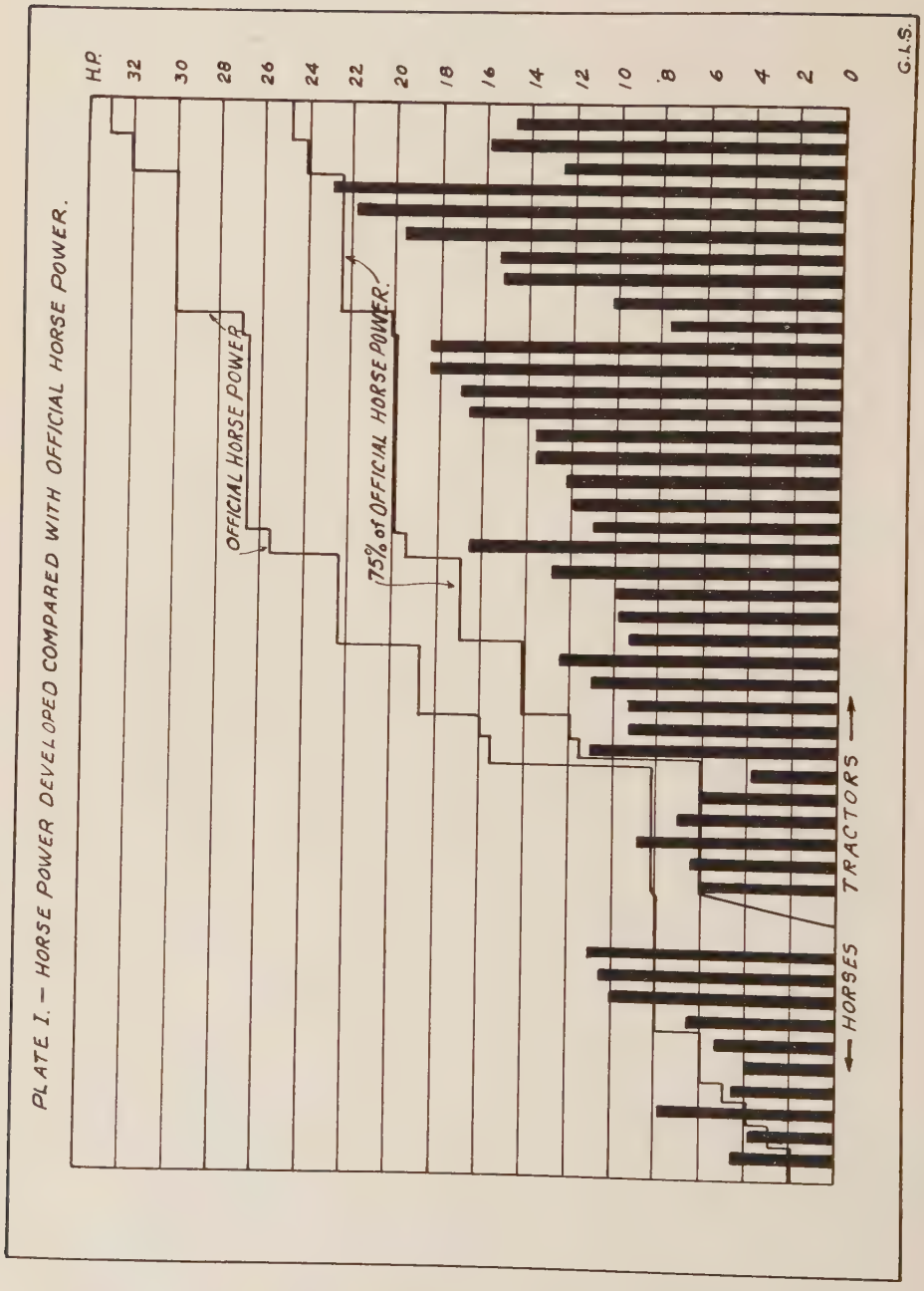
PLATE I. — HORSE POWER DEVELOPED COMPARED WITH OFFICIAL HORSE POWER.
H.P.
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
OFFICIAL HORSE POWER
75% of OFFICIAL HORSE POWER.
HORSES
TRACTORS
G.I.S.

ten tests were horse outfits and the remainder were tractors. Above the vertical bars is drawn a series of horizontal reference lines joined for convenience by vertical lines. These horizontal lines marked "Official Horse Power" denote, in the case of horse outfits, the number of horses; in the case of tractors, the position of the line denotes the maximum drawbar horse power of the tractor according to the Nebraska tractor tests. In the case of the tractor tests a second series of horizontal lines marked "75% of Official Horse Power" is also shown on the graph for reference purposes, it being the opinion of the authors that this proportion of the maximum power is all that can be safely utilized under field conditions. An examination of the graph shows, therefore, that in the case of horse outfits six out of the ten were overloaded—some, as for example No. 3, to a marked degree—and that the surplus power in the other horse tests is not excessive. For tractors, it will be noted that only six of the thirty-five reach, or pass, the 75% line, and that the margin of surplus in the average case is large. The tractor tests are arranged in groups according to their power, the smallest being on the left and largest on the right. In general it will be noted that the smaller tractors are more nearly fully loaded than are the larger ones. From the results of these tests the following conclusions are drawn.

Conclusions

1. The limited number of tests made and their restriction to one general soil type in so far as tillage implements are concerned does not justify any sweeping conclusions or broad generalizations. The following tentative conclusions seem fairly justified by the present work.

(a) Horse outfits are more likely to be loaded to capacity than are tractor outfits.

(b) Higher overloads will be found with horse outfits than with tractor outfits.

(c) The smaller tractors are more nearly loaded to capacity than the larger tractors.

(d) As the size of the tractor increases, the probability of it being loaded to capacity decreases. The three tractors to the extreme right of the graph (Plate I) are the largest in the group and none of these were loaded to 50% capacity.

(e) The speed of horse drawn outfits which averages 2.68 miles per hour is somewhat higher than the usual assumption of 2.5 m.p.h.

2. The ease with which the number of horses used may be varied to suit the draft requirements of an implement is an important advantage of horse operated implements which is not usually stressed.

3. As the draft of any implement varies with soil types, depth and soil condition, the tractor operated machine must be of a size that its draft under the worst conditions will not exceed the tractor's capacity. This means that under more favourable conditions the tractor will be underloaded as shown in these tests.

4. There is definite need for more information as to the draft requirements of the various farm implements.

5. A draft survey of the various soil types in Manitoba is urgently needed if farmers are to obtain the maximum efficiency from either horses or tractors.

Summary

The draft tests made during the survey show conclusively that the average operator has little idea of the power being developed by his horses or tractor. In the case of horse drawn implements we have an example of three horses pulling the same load as six horses and of four horses pulling practically as much as eight horses. In so far as horse operators are concerned the odds seem to be just as great that the horses will be overloaded as underloaded.

With tractors a fixed maximum cannot be exceeded, and as a close approach to this results in operating difficulties, practically all tractors tested were found to be underloaded. No simple method for determining when the tractor has an adequate load is available to the farmer, and therefore the average tractor in these tests was found to be operating with an inefficient load.

RESUME

L'emploi efficace de l'énergie motrice sur la ferme. H. R. Robson et G. L. Shanks, Université du Manitoba, Winnipeg, Man.

Les essais de traction qui ont été effectués ont démontré de façon concluante que le conducteur ordinaire ne se fait qu'une idée très vague de l'énergie développée par ses chevaux ou ses tracteurs. Dans le cas de machines tirées par des chevaux, nous avons un exemple de trois chevaux tirant la même charge que six chevaux, et de quatre chevaux tirant à peu près autant que huit chevaux. En ce qui concerne les conducteurs de chevaux, il y a tout autant de chance pour les chevaux d'être surchargés que d'être trop peu chargés. Avec les tracteurs on ne peut pas dépasser un maximum fixé, et comme on éprouve des difficultés de conduite lorsqu'on se rapproche de ce maximum, presque tous les tracteurs essayés ont été trouvés sous-chargés. Il n'existe pas de moyen simple pour déterminer si le tracteur a une charge suffisante, et c'est pourquoi on a trouvé que le tracteur ordinaire dans ces essais fonctionnait avec une charge inefficace.

CEREAL GRAIN CROPS FOR ANNUAL PASTURE

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[Received for publication May 5, 1934]

Annual pasture crops are important in many parts of Canada. In the prairie provinces perennial grasses and legumes cannot be depended upon to supply grazing during the periods of dry weather which occur almost every season. This is the case also, though not to the same extent, in Ontario and Quebec. The most feasible method of overcoming this difficulty is to seed one of the grain crops to provide pasturage when the perennial grasses are unproductive.

The cereals used as annual pasture crops are oats, barley, wheat, and spring rye, oats being by far the most important for this purpose. Barley is used also to a considerable extent. Spring rye is seeded for pasture in the driest sections of the West and wheat is sometimes used when other seed is not available. Sometimes two or more of the cereal grains are mixed. Another favorite combination is a mixture of oats and fall rye, the latter to supply green vegetation in the autumn after the oats are eaten off, or harvested for green feed.

There are certain questions relating to the use of cereal grains for pasture that have not been investigated. Definite information is lacking on the relative productivity and nutrient value of the different cereals. It is not known which of them has the greatest power of regrowth after being eaten off and which of them will produce the greatest number of pasture crops in a single season. Several other questions also require answering. What is the best time to begin pasturing? How does the percentage of protein in the herbage compare at different stages of growth? Will the fresh young growth provide a high protein feed as is the case with perennial grasses, and if so is the total seasonal yield of protein satisfactory? Are the results better with early than with late seeding, and how do the different cereal crops compare in this respect?

In order to answer these questions an experiment was started in the spring of 1932 at the Dominion Experimental Farm, Indian Head, Saskatchewan. Four cereals were grown, namely, oats, barley, wheat and spring rye. These were cut with a horse mower to simulate grazing. Provision was made for five plots of each cereal, clipping to begin at different stages of growth, approximately as follows, and thereafter as often as the growth reached a height of 7 to 8 inches: (1) 3–leaf stage; (2) 5–leaf stage; (3) shot blade; (4) early heading; (5) fully headed. The 3–leaf stage corresponded to a height 4 to 5 inches and the 5–leaf stage to a height of 6 to 8 inches. These measurements refer to the leaf mass. If the full length of the leaves had been measured, the heights would have been considerably more than those stated. One series in duplicate (designated first and second series) was seeded early, about May 20, and a second seeding in duplicate was started late, about June 12. All samples were air-dried and forwarded

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to the Dominion Experimental Farm at Ottawa, where dry matter and protein analyses of the herbage were made by the Division of Chemistry. Two years' records are now available from this experiment, and results of considerable interest have been obtained.

The season of 1932 differed considerably from that of 1933 with respect to the amount and distribution of rainfall. Precipitation from April to July inclusive was almost equal to the 25-year average, but the season began with practically no reserve soil moisture and it was very dry up until May 22. After this date the supply of moisture was satisfactory until the middle of July. Late July and early August was exceedingly hot and dry but the rainfall for the month of August was above average. The season of 1933, on the other hand, was much more favourable for forage crops. Plenty of snow cover during the winter of 1932-1933 provided excellent growing conditions at time of seeding and good rains were received at fairly regular intervals during May and June.

Experimental Data

The yield data on dry matter and protein from the first and second series for both the early and late seedings are summarized in Tables 1, 2 and 3. Table 1 contains the data for the early seeding, Table 2 for the late seeding, and Table 3 gives averages for dates of seeding and duplicate series in 1932-1933. In all three tables the data are presented for each stage of growth when clipping of the plots was begun.

Average yields of dry matter per acre and protein percentages for the early seeding of the different cereal crops are shown graphically in Figure 1. The "stage of growth" indicates the vegetative period when clipping was begun and the yields for each vegetative period include all subsequent clippings. It is apparent that the total yield of dry matter increased as the stage of growth advanced, whereas the percentage of protein became less as the first cutting was delayed. As the yield of dry matter increased, the protein content decreased. This was the case with all four cereal crops.

Figure 2 gives the data corresponding to that shown in Figure 1, but for a later date of seeding. The trends in yields of dry matter and protein content were almost identical but the yields of the former were less. It is worthy of note that in both graphs, and with respect to both the yield and protein content, the four crops maintain the same order from highest to lowest, namely oats, barley, wheat, rye.

Figures 3 and 4 show the total yields of protein per acre for the early and late seedings respectively of the four cereal crops. These graphs are the more significant because they combine yield of dry matter with protein content and present a substantially true picture of the relative feeding value of each crop when utilized as pasture. The outstanding value of oats is clearly evident. Barley comes next, followed by wheat and spring rye. The advantage of early seeding was more pronounced in the case of oats than in that of the other cereals due in part at least to its ability to produce a larger number of successive crops of herbage.

In the case of oats at the early date of seeding, it is apparent that the maximum yield of protein per acre was obtained when cutting was begun at the 5–leaf stage. At the later date of seeding, the 3–leaf stage was somewhat better than the 5–leaf stage. In the case of wheat and rye,

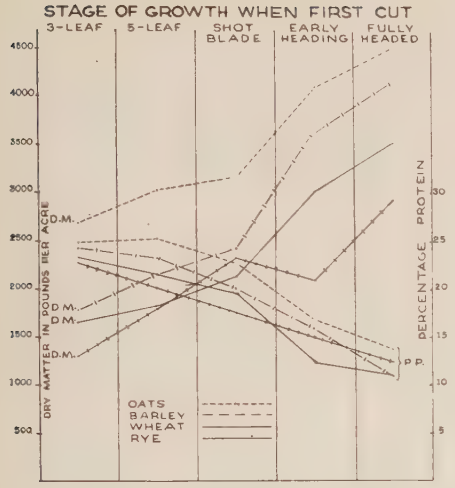

FIGURE 1. Graph showing the total average seasonal yields of dry matter and the protein percentages as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Early seeding: 1932 and 1933.)

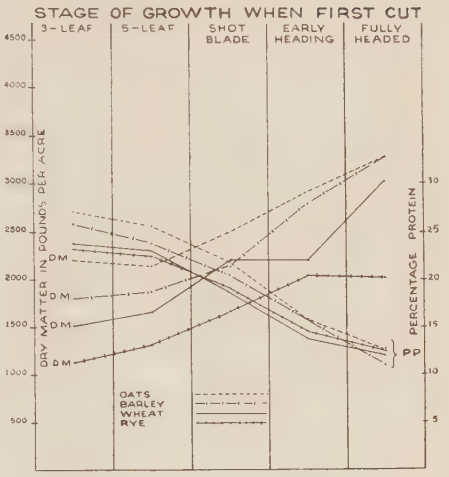

FIGURE 2. Graph showing the total average seasonal yields of dry matter and the protein percentages as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Late seeding: 1932 and 1933.)

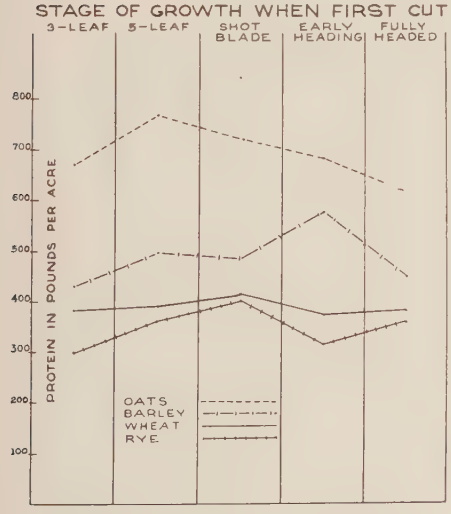

FIGURE 3. Graph showing the total average seasonal yields of protein as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Early seeding: 1932 and 1933.)

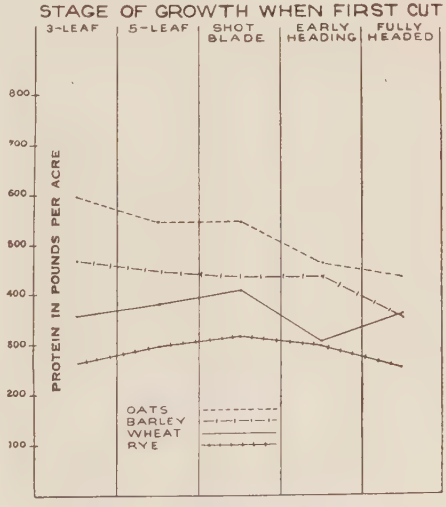

FIGURE 4. Graph showing the total average seasonal yields of protein as determined for the first cutting at the stage of growth indicated, including all successive pasture cuts. (Late seeding: 1932 and 1933.)

largest yields were obtained by starting to cut when the plants were in the shot blade. The results with barley were less consistent and it is difficult to account in Figure 3 for the high point reached by this crop at early heading.

In view of the evident superiority of oats for pasture over the other three cereals, it seemed worth while to set forth diagramatically the yields of dry matter and of protein per acre which were obtained from each of the cereal crops at each cutting. By so doing a picture could more easily be obtained of the number of pasture cuts per season and the consistency with which these were maintained throughout the season. The latter is a measure of the power of regrowth possessed by the different cereals. Figures 5 and 6 give this information with respect to acre yields of dry matter and protein respectively when cutting was begun at the 3–leaf stage. Figures 7 and 8 present the same data when cutting was started at the 5–leaf stage. Figures 5 to 8 inclusive refer to the early date of seeding only, and each shows the comparative yields for 1932 and 1933 as well as the average results for these years.

It is almost unnecessary to detail the significant features which are so clearly evident in these diagrams. Oats invariably gave the lowest yield at the first cut but the productivity of this crop was much the best sustained. In 1932, when cutting was begun at the 3–leaf stage, oats produced 5 cuts as compared with 4 for barley, wheat and rye. In 1933 oats gave 7 cuttings as compared with 4 for the other crops. The smallness of the first cut in 1932 was due to the very dry weather conditions in the spring, while moisture conditions were excellent in the spring of 1933 resulting in good growth from the start. It is very noticeable that oats continued to produce substantial yields after the other cereals had ceased to grow. The best single comparison may be made by an examination of the total average yields of protein per acre. These are shown in Figures 6 and 8.

Discussion of Results

The superiority of oats as the one best annual hay crop has been generally recognized throughout Canada and experimental investigations have strongly supported practical experience in this connection. It is not so clearly appreciated, however, that oats are also the best annual pasture crop. The data submitted herein supports the view that the oats crop is even more valuable for pasture than for hay as compared with the other cereals. This is clearly shown in Figure 3 when the spread in yield at the 5–leaf stage of growth is compared with the spread in yield when the oats are fully headed. Such a comparison is legitimate since the last stage of growth at which the cereals were cut is comparable to the vegetative period at which they should be cut for hay. It should be pointed out also that the total yield reported for oats at the "fully headed" stage includes an appreciable amount of aftermath which would not normally be included in the yield of hay.

If we take the 5–leaf stage of growth as an appropriate basis of comparison between oats and the other cereals for pasture purposes, it will be seen from an examination of Figures 3 and 4 that the total yield of protein per acre in early seeded oats exceeded that of barley by about 54%, wheat by 96% and spring rye by 112%. At the later date of seeding oats exceeded

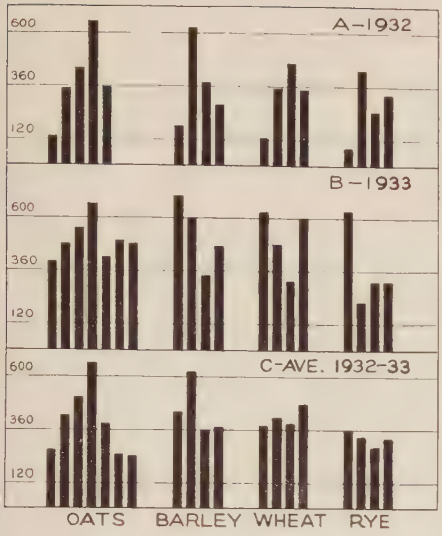

FIGURE 5. Yields of dry matter in pounds per acre from successive cuttings beginning at the three-leaf stage. (Early seeding.)

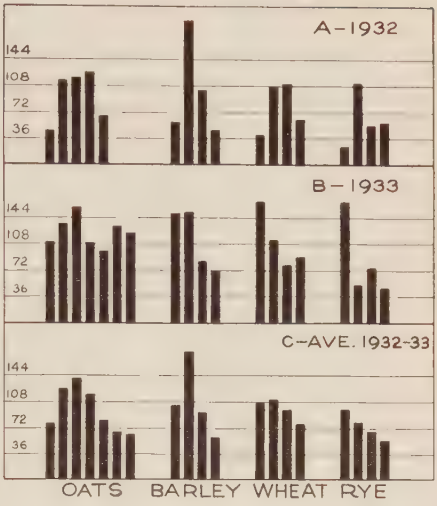

FIGURE 6. Yield of protein in pounds per acre from successive cuttings beginning at the three-leaf stage. (Early seeding.)

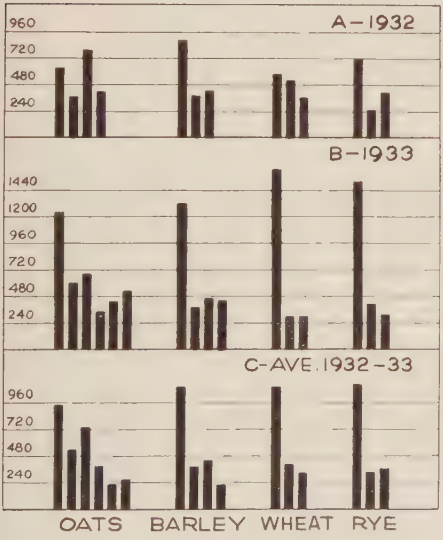

FIGURE 7. Yields of dry matter in pounds per acre from successive cuttings beginning at the five-leaf stage. (Early-seeding.)

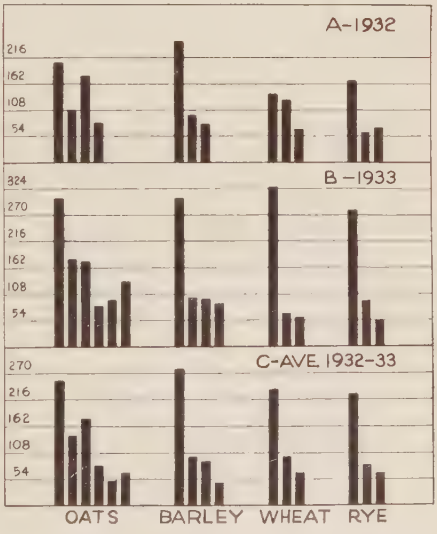

FIGURE 8. Yields of protein in pounds per acre from successive cuttings beginning at the five-leaf stage. (Early seeding.)

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TABLE 1.—SEASONAL YIELDS OF DRY MATTER AND PROTEIN IN POUNDS PER ACRE FROM THE EARLY SEEDING*

Crop	Stage of growth at first cutting	1932						1933					
		1st Series			2nd Series			1st Series			2nd Series		
		No. times cut	Dry matter	Protein	No. times cut	Dry matter	Protein	No. times cut	Dry matter	Protein	No. times cut	Dry matter	Protein
Oats	3–leaf	5	1826	500	5	1961	454	7	3664	921	7	3323	813
	5–leaf	4	2362	628	4	2034	511	6	4228	1058	6	3486	872
	Shot blade	3	2060	439	3	1792	325	5	4418	1063	5	4397	1059
	Early heading	2	2754	431	2	2901	449	4	5565	961	4	5161	895
	Fully headed	1	3223	477	1	3347	429	2	5813	791	2	5719	776
Barley	3–leaf	4	1556	466	4	1358	352	4	2373	510	4	1853	400
	5–leaf	3	1890	491	3	1512	351	4	2703	604	4	2472	558
	Shot blade	2	2321	438	2	855	154	3	3227	667	3	3299	686
	Early heading	1	2543	383	1	2614	394	2	4799	730	2	4546	696
	Fully headed	1	3977	520	1	1669	195	1	5368	524	1	5586	545
Wheat	3–leaf	4	1537	409	4	1025	235	4	2282	503	4	1747	389
	5–leaf	3	1741	409	3	1181	257	3	2545	521	3	1806	374
	Shot blade	2	2331	412	2	1306	230	3	2649	545	2	2210	468
	Early heading	1	2822	369	1	1890	247	2	4009	479	2	3339	398
	Fully headed	1	2451	304	1	1919	249	1	4934	504	1	4780	489
Rye	3–leaf	4	1334	325	4	851	181	4	1903	424	4	1132	253
	5–leaf	3	1642	372	3	1103	232	3	2434	468	3	2015	375
	Shot blade	2	2911	497	2	1498	255	2	2624	467	2	2252	402
	Early heading	1	2285	298	1	1655	215	2	2338	387	2	2093	350
	Fully headed	1	3173	340	1	1811	213	2	3611	477	1	3084	409

*Dates of seeding, May 21, 1932, and May 20, 1933.

TABLE 2.—SEASONAL YIELDS OF DRY MATTER AND PROTEIN IN POUNDS PER ACRE FROM LATE SEEDING*

Crop	Stage of growth at first cutting	1932						1933					
		1st Series			2nd Series			1st Series			2nd Series		
		No. times cut	Dry matter	Protein	No. times cut	Dry matter	Protein	No. times cut	Dry matter	Protein	No. times cut	Dry matter	Protein
Oats	3–leaf	4	2086	574	4	1605	425	6	3171	861	6	1940	525
	5–leaf	4	2064	531	2	1014	246	5	3150	811	4	2365	602
	Shot blade	3	1993	464	3	1420	376	4	3384	693	4	3259	672
	Early heading	2	2574	490	2	2025	384	2	4202	596	2	2905	380
	Fully headed	2	2811	348	2	3347	429	2	3961	508	2	3017	387
Barley	3–leaf	3	1638	459	2	1121	300	5	2539	646	4	1928	469
	5–leaf	3	1359	343	3	1476	334	4	2531	620	3	2088	487
	Shot blade	1	1975	397	1	758	152	2	2849	591	2	2962	608
	Early heading	1	2157	369	1	1544	264	2	4099	613	2	3380	507
	Fully headed	1	1669	195	1	1669	195	1	5017	536	1	4685	500
Wheat	3–leaf	2	1146	282	2	780	187	4	2098	509	4	2016	457
	5–leaf	2	1357	324	2	1087	211	3	2317	575	3	1857	416
	Shot blade	2	1986	358	2	985	182	2	3147	594	2	2716	506
	Early heading	1	1954	292	1	1634	244	1	2946	385	1	2278	298
	Fully headed	1	1319	171	1	1919	249	1	4624	527	1	4433	506
Rye	3–leaf	2	1200	305	2	758	183	4	1806	399	4	787	170
	5–leaf	2	1271	268	2	985	203	3	1599	380	3	1441	332
	Shot blade	2	1788	311	2	1166	203	2	2034	410	2	1670	340
	Early heading	2	1826	261	2	1733	256	2	2272	326	2	2328	334
	Fully headed	2	2534	318	1	1811	213	1	1981	255	1	1717	221

*Dates of seeding, June 14, 1932, and June 12, 1933.

TABLE 3.—AVERAGE YIELDS OF DRY MATTER AND PROTEIN IN POUNDS PER ACRE OF DUPLICATE SERIES AND DATES OF SEEDING FOR 1932–1933

Cereal	Stage of growth at first cutting	May Sowing						June Sowing					
		1932 1st and 2nd series		1933 1st and 2nd series		Average 1932–33		1932 1st and 2nd series		1933 1st and 2nd series		Average 1932–33	
		Dry matter	Protein	Dry matter	Protein	Dry matter	Protein	Dry matter	Protein	Dry matter	Protein	Dry matter	Protein
Oats	3–leaf	1893	477	3493	867	2694	672	1845	499	2555	693	2201	596
	5–leaf	2198	569	3857	965	3028	767	1539	388	2757	706	2148	548
	Shot blade	1926	382	4407	1061	3167	722	1706	420	3321	682	2514	551
	Early heading	2827	440	5363	928	4095	684	2300	437	3553	488	2927	463
	Fully headed	3285	453	5766	783	4526	618	3079	388	3489	447	3284	418
Barley	3–leaf	1457	409	2113	455	1785	432	1379	379	2233	557	1807	469
	5–leaf	1701	421	2587	581	2144	496	1417	338	2309	553	1864	446
	Shot blade	1588	296	3263	676	2426	486	1366	274	2905	599	2136	437
	Early heading	2578	388	4672	713	3626	576	1850	316	3739	560	2795	438
	Fully headed	2873	357	5477	534	4150	446	1669	195	4851	508	3260	357
Wheat	3–leaf	1281	322	2014	446	1648	384	963	234	2057	483	1510	359
	5–leaf	1461	333	2175	447	1818	390	1222	267	2087	495	1655	382
	Shot blade	1818	321	2449	506	2124	414	1485	270	2931	550	2209	410
	Early heading	2356	308	3674	438	3015	373	1794	268	2612	341	2203	305
	Fully headed	2185	277	4857	496	3521	387	1619	210	4528	516	3024	363
Rye	3–leaf	1092	253	1517	338	1306	296	979	244	1296	284	1138	264
	5–leaf	1372	302	2224	421	1798	362	1128	235	1520	356	1324	296
	Shot blade	2204	376	2438	434	2321	405	1477	257	1852	375	1665	316
	Early heading	1970	256	2215	368	2093	313	1779	258	2300	330	2040	294
	Fully headed	2492	276	3347	443	2920	360	2172	265	1849	238	2011	252

barley in yield of protein per acre by 23%, wheat by 53%, and spring rye by 85%. Oats proved to be much the better pasture crop, therefore, whether they were compared on the basis of early or late seeding. Their superiority, however, was most pronounced with early seeding.

The total seasonal yield of oats herbage from the early seeding when cutting began at the 5 leaf stage was slightly over 3,000 pounds per acre and the average protein content for all cuttings was about 25%. The corresponding yield at the same stage of growth for the later seeding was about 2,500 pounds with a similar protein content. In both cases the average time between the first and last cuttings was approximately 80 days. The larger yield of 3,000 pounds would be equivalent to a carrying capacity of 100 cow days or 1.25 cows per day for the 80 day period. Pasture experiments conducted at the Central Experimental Farm, Ottawa, by the Divisions of Animal Husbandry and Field Husbandry, over a period of 5 years, have shown that first class blue grass pasture had an average carrying capacity of 70 cow days per season. An adjacent fertilized area had a carrying capacity of 90 cow days. The average protein content based on samples of the herbage taken at monthly intervals during each of three seasons was 20%. The comparison between oats and blue-grass is very favourable to the former with respect to both yield and protein content. It is true that the oats were grown in Saskatchewan and the blue-grass in Ontario, but this does not make the comparison any less interesting or significant.

Experiments on three fields to determine the carrying capacity of cereals as annual pasture crops under actual grazing conditions were begun in 1933 at the Dominion Experimental Farm, Indian Head. The results tend to substantiate our estimate of the carrying capacity based on the yields from clipped plots. It will be necessary to repeat these tests for three or four years in order to obtain reliable data. A pasture experiment also with perennial species on four fields was laid down in 1933 and this will be subjected to controlled grazing in 1934. This will make it possible to obtain a comparison between oats on the one hand and on the other, brome grass, western rye grass, crested wheat grass, and a mixture of all the grasses with alfalfa.

When oats are used as an annual pasture crop, too often they are not grazed in practice until the early heading or fully headed stage of growth. The question arises as to whether cereal crops, and oats in particular, should not be subjected to grazing at an earlier stage of development. Generally speaking, of course, supplementary pastures will be utilized when they are needed, but assuming that additional pasturage is required, it is important to know how soon pasture may be or should be grazed to produce satisfactory results. There is also the question as to what will be the effect of early grazing on the total yield of nutrients and whether early grazed oat herbage will provide an adequate protein-rich diet together with a satisfactory bulk of organic matter.

From the results of this experiment it is evident that early seeded oats has produced the greatest yields of protein per acre when cutting began at the 5–leaf stage. Later seeding gave the largest yields when cutting was started at the 3–leaf stage. In the latter case growth was more rapid from the beginning due to higher temperatures, but the seasonal

yield was considerably less. It would appear, therefore, that, with proper management, the grazing of oats should begin about the 5-leaf stage in order to secure the maximum feeding value. The same cannot be said of any of the other cereals, but the data shows that any of these crops can be pastured at an early stage of growth if so desired without reducing the total yield of protein. It is recognized that when fields are grazed there will be a certain amount of wastage but this can be very largely avoided by good management in handling the live stock. On the other hand, grazing has some advantages over cutting as the latter treatment, being rather drastic, tends to suppress growth.

The relative amounts of dry matter in the fresh cut herbage merit some attention from a pasture standpoint. Considering only the two earliest cuts beginning at the 3-and 5-leaf stages of growth from both the early and late seedings it was found that the average percentage of dry matter for oats, barley, wheat and rye was 14.2, 15.3, 18.2 and 18.0% respectively. This shows that the oats and barley were more succulent than the wheat and rye and it also raises the question whether animals could consume a sufficient quantity of oats or barley herbage at these early stages of growth to give them the amount of feed which they need.

A dairy cow on full ration requires in the neighbourhood of 30 pounds of dry matter in each 24 hours. Assuming that she had access only to the fresh young herbage of annual pasture crops containing 15% of dry matter, she would have to consume 200 pounds of green material per day. Whether she could do this or not is open to question but it is a fact that animals will eat a considerably larger quantity of fresh young herbage as pasture than if the same material were supplied to them in the wilted or dry condition. Apart from the bulkiness of the feed, this degree of succulence in a sole ration is undoubtedly undesirable because of its laxative effect as compared with one of a higher dry matter content. It would seem, and experience indicates, that if animals are to be grazed on young herbage with such a high moisture content they should be provided with a certain amount of dry feed as well. On account of the high protein content oats pasture at the early stages of growth admits of this without unduly lowering the protein content, and the addition of dry roughage or other carbonaceous feed as a pasture supplement will tend to provide a better balanced ration.

The high protein content of fresh young herbage of the cereal crops is worthy of special consideration from a feeding standpoint. Figures 1 and 2 show the relative protein content at the different stages of plant development. With all crops, the decrease is consistently downward after the 5-leaf stage. At this stage oats contain an average of 25% of crude protein and it does not fall below 20% until after the shot blade stage is reached. These facts definitely place young oat herbage in the class of a highly concentrated protein feed. The protein of young grass is approximately 75% digestible and assuming that the same applies to oats we can say that the oat herbage in the leafy stages contains sufficient digestible nutrients to supply the requirements of the heaviest producing milch cows. As a matter of fact, a 1,000 lb. cow producing 3 gallons of milk per day would have an adequate protein diet if only one-half of her ration was derived from oat pasture and the other half from hay or other roughage.

Recognition of the fact that young oat pasturage may be regarded as a protein concentrate should enable the feeder, under certain conditions

to reduce his outlay for commercial feeds, or provide additional pasturage in critical periods. As a rule there is no lack of pasture during the flush of growth in the early part of the season but sometimes this is not the case and almost invariably the pastures fail in July and August. Under these circumstances it is well to know the relative value of annual crops for pasture and to appreciate the excellence of oats for this purpose.

Summary

1. Oats, barley, wheat and spring rye were compared with reference to yield, feeding value and utilization as annual pasture crops.

2. With respect to yield of dry matter per acre and percentage of protein, oats were always superior to barley, followed in order by wheat and spring rye.

3. In total average yield of protein per acre from the early seeding, oats exceeded barley by 54%, wheat by 96%, and spring rye by 112%. At the later date of seeding oats exceeded barley by 23%, wheat by 53%, and rye by 85%.

4. The total pasture yield of all crops increased and the percentage protein decreased as the first date of cutting was delayed.

5. Oats had a lower dry matter content than the other cereal crops.

6. Oats produced 5 cuttings in 1932 and 7 cuttings in 1933 as compared with 4 cuttings in both seasons by the other three crops.

7. Largest yields of protein per acre were obtained from oats when pasture cuttings were begun at the 5–leaf stage.

8. Oats from the early seeding produced 3,000 pounds of dry matter per acre with an average protein content of 25%. This is equivalent to a greater carrying capacity than was obtained at Ottawa on good quality native blue-grass sod.

9. Young oats herbage may be regarded as a highly concentrated protein feed.

RESUME

Céréales pour pâturages annuels. L. E. Kirk, J. G. Davidson et Stella N. Hamilton, Ferme expérimentale fédérale, Indian Head, Saskatchewan.

L'avoine, l'orge, le blé et le seigle de printemps ont été comparés l'un à l'autre pour le rendement, la valeur alimentaire et l'utilisation comme plantes annuelles à pacage. En ce qui concerne le rendement de matière sèche par acre et le pourcentage de protéine, l'avoine s'est toujours montrée supérieure à l'orge; viennent ensuite le blé et le seigle de printemps. Au point de vue du rendement moyen total de protéine par acre dans la récolte provenant des premières semailles, l'avoine a dépassé l'orge par 54%, le blé par 96% et le seigle de printemps par 112%. Dans la récolte provenant des dernières semailles, l'avoine a dépassé l'orge par 23%, le blé par 53% et le seigle par 85%. Le rendement total en pâturage de toutes les récoltes augmentait tandis que le pourcentage de protéine diminuait à mesure que la première date de coupe était retardée. L'avoine avait une proportion de matière sèche plus faible que les autres céréales. L'avoine a produit cinq coupes en 1932 et sept coupes en 1933, tandis que les trois autres récoltes donnaient quatre coupes dans les deux saisons. L'avoine a donné le rendement le plus élevé de protéine par acre lorsque les coupes ont été commencées quand la plante avait cinq feuilles. L'avoine des premières semailles a produit 3,000 livres de matière sèche par acre et une proportion moyenne de protéine de 25%. Ceci représente une quantité de nourriture plus forte que celle que l'on a obtenue à Ottawa sur gazon de pâturin indigène de bonne qualité. On peut en conclure que l'herbage de jeune avoine est un aliment protéique hautement concentré.

THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, LARGELY FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada declined from 72.0 in March to 71.1 in April. The recessions in the vegetable products group and animals and their products were quite marked. The index of chemicals and allied products rose from 80.8 to 81.8, while that of iron and its products was unchanged, other sub-indexes moved downward.

Retail Prices.—The total index of retail prices, rents and costs of services receded from 80.2 in March to 79.6 in April. The index of prices of foods dropped from 72.9 to 71.0. The fuel index advanced from 87.3 to 87.6.

Physical Volume of Business.—The index of physical volume of business was 92.6 in April as compared with 93.1 in March. Industrial production moved downward from 92.0 to 91.4. Mineral production, car loadings and exports were higher. In the manufacturing group activity in automobile production was outstanding. Sugar output was also much higher than in the preceding month. Production of newsprint was just about maintained. Electric power was off slightly. Construction failed to show the anticipated gain. While production as a whole was not as active as in March, it will be recalled that the production indexes rose sharply between February and March of this year.

Agricultural Products.—The index of wholesale prices of Canadian farm products was 55.4 in April as against 56.5 in March, a decline of a little over one point. In the field products group the index fell from 49.7 to 48.7, lower prices for wheat, oats, barley and rye were chiefly responsible. Animal products dropped from 68.3 to 66.6, lower prices for hogs, calves, wool and eggs more than offset advances in the prices of cattle, fresh milk, hides and skins.

The primary movement of wheat was 196,754,313 bushels during the period August 1, 1933, to May 4, 1934. In 1932-33, during the corresponding period, 331,716,868 bushels were marketed.

The live stock market report published by the Live Stock Branch of the Federal Department of Agriculture states that for 21 weeks of 1934 ended May 24, sales of cattle at public yards were 238,166 head as compared with 204,913 for the same period of 1933. Sales of calves for the corresponding periods were 140,611 as against 119,717, those of sheep 74,314 where as in 1933, they were 77,631. Shipments of hogs both to public yards and direct to packing plants were 1,339,845, while in 1933 during this period 1,353,323 hogs were sold through these outlets.

During April agricultural marketings declined to 56.9. The index of grain marketings dropped from 58.7 in March to 49.3. There was an increase in the movement of live stock, the index rising from 86.4 to 90.6.

The index of cold storage holdings at the first of April stood at 94.5, this index, however, rose to 102.6 at the first of May, increased stocks of butter, veal and poultry were reported, whereas stocks of lard declined.

Exports of Agricultural Products.—Exports of Canadian agricultural and vegetable products for the twelve months ending March, 1934 were valued at $205,804,526 as compared with $203,370,418 during the twelve months period ending March, 1933. The volume of exports of the more important agricultural products during these two periods is set forth in Appendix Table 1.

Examination of Appendix Table 1 shows clearly that exports of apples, canned fruits, potatoes, canned vegetables, wheat flour, flax seed, cattle, bacon and hams, fresh beef, canned meats, eggs and wool have increased in volume. The decreases have taken place in fruit juices and syrup, barley, oats, rye, wheat, maple sugar, tobacco leaf and cheese. Among these products, the reduction in exports of wheat and tobacco leaf is most significant.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION
COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.9	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933									
Jan.	63.0	43.6	35.1	57.9	79.1	68.1	62.2	56.1	112.0
Feb.	63.6	43.0	36.0	54.7	78.4	67.0	60.0	76.5	127.6
Mar.	64.4	44.7	38.0	56.0	77.8	68.4	62.5	129.0	135.8
April	65.4	46.8	41.1	56.4	78.1	69.8	65.1	104.1	112.7
May	66.9	51.2	46.9	58.4	77.0	76.4	72.7	95.4	110.4
June	67.6	52.6	49.4	57.9	77.0	82.2	79.8	221.9	119.9
July	70.5	60.1	60.8	59.0	77.2	84.1	82.6	221.9	119.9
Aug.	69.4	57.0	54.9	60.5	78.6	89.8	89.5	197.2	114.2
Sept.	68.9	54.7	49.5	63.4	78.8	90.8	90.2	101.1	115.7
Oct.	67.9	51.4	44.6	62.8	77.9	88.2	87.4	70.5	112.7
Nov.	68.7	53.8	46.7	65.8	78.1	85.5	83.9	41.8	111.1
Dec.	69.0	53.3	45.3	66.6	78.4	86.2	85.1	30.7	107.6
1934									
Jan.	70.6	55.3	47.9	67.8	78.7	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	79.2	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	80.2	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.6	92.6	91.4	56.9	94.5

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913–1931, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

Prices in United States.—The index of wholesale prices in United States (1910–14 = 100) was 108 in March of this year, the farm price index for all groups of agricultural products was 74.0 as compared with 56.0 in April, 1933.

Appendix Table 1

Volume of exports of principal Canadian farm products in the twelve months periods ending March 1933 and 1934 [1]

Product	Unit	Amount		Product	Unit	Amount	
		1933	1934			1933	1934
Apples, fresh	bbls.	1,780,026	3,476,114	Wheat flour	bbls.	5,268,371	5,619,937
Fruit, canned	lbs.	9,787,956	17,547,577	Maple sugar	lbs.	3,176,471	2,295,042
Fruit juices and syrups	gals.	423,168	300,318	Clover seed	bush.	68,121	117,405
Potatoes	bush.	1,861,843	2,707,693	Flax seed	bush.	371,438	610,327
Turnips	bush.	1,950,482	1,949,022	Tobacco leaf	lbs.	14,748,069	8,460,639
Canned vegetables	lbs.	6,755,112	17,099,688	Cattle	No.	37,359	64,209
Barley	bush.	9,863,054	1,569,569	Bacon and hams	cwt.	402,101	960,178
Oats	bush.	13,824,742	5,707,502	Beef, fresh	cwt.	50,879	102,771
Rye	bush.	8,211,332	2,788,213	Canned meats	cwt.	602,966	973,218
Wheat	bush.	239,373,255	175,534,255	Cheese	cwt.	857,116	749,669
Bran, shorts, middlings	cwt.	2,142,785	2,598,860	Eggs	doz.	270,340	2,122,904
				Honey	lbs.	2,679,536	2,306,248
				Raw wool	—	4,020,751	10,903,821

[1] Summary Trade of Canada, March, 1934.

LA SITUATION ÉCONOMIQUE

PRÉPARÉ PAR LA DIVISION DE L'ÉCONOMIE AGRICOLE, DU MINISTÈRE DE L'AGRICULTURE, À OTTAWA, ET BASÉ PRINCIPALEMENT SUR LES DONNÉES RECUEILLIES PAR LE BUREAU FÉDÉRAL DE LA STATISTIQUE

L'indice des prix de gros au Canada, qui était de 72.0 en mars, est descendu à 71.1 en avril. La rétrogression dans le groupe des produits végétaux et les animaux et leurs produits a été très marquée. L'indice des produits chimiques et alliés s'est élevé de 80.8 à 81.8 tandis que celui du fer et de ses produits n'a pas changé. Les autres sous-indices ont baissé.

Prix de détail.—L'indice total des prix de détail, des loyers, et des frais de service est descendu de 80.2 en mars à 79.6 en avril. L'indice des prix des denrées alimentaires est descendu de 72.9 à 71.0. L'indice des combustibles est monté de 87.3 à 87.6.

Indice du volume physique des affaires.—L'indice du volume physique des affaires était à 92.6 en avril contre 93.1 en mars. La production industrielle est descendue de 92.0 à 91.4. La production minérale, les chargements de wagons et les exportations ont remonté. Dans le groupe manufacturier il y avait une grande activité dans l'industrie de l'automobile dont la production a été remarquable. La production du sucre a été également beaucoup plus élevée que le mois précédent. La production du papier à journal n'a fait que se maintenir. L'énergie électrique a un peu baissé. Le bâtiment n'a pas enregistré le gain que l'on attendait. La production en général n'a pas été aussi active qu'en mars, mais il est à noter que les indices de la production s'étaient élevés brusquement entre février et mars de cette année.

Produits agricoles.—L'indice des prix de gros des produits agricoles canadiens était de 55.4 en avril contre 56.5 en mars, soit une baisse d'un peu plus d'un point. Dans le groupe des produits des champs, l'indice est passé de 49.7 à 48.7, surtout à cause de la baisse des prix du blé, de l'avoine, de l'orge et du seigle. Les produits animaux, qui étaient à 68.3 sont descendus à 66.6, la baisse des prix pour les porcs, les veaux, la laine et les œufs a contrebalancé et au-delà les hausses enregistrées dans les prix des bovins, du lait frais, des cuirs et des peaux.

Le mouvement préliminaire du blé a été de 196,754,313 boisseaux entre le 1er août 1933 et le 4 mai 1934. Pendant la période correspondante en 1932-33 il s'était vendu 331,716,868 boisseaux.

Le rapport sur le commerce des bestiaux publié par la Division de l'Industrie animale du Ministère fédéral de l'Agriculture, établit que pendant les 21 semaines de 1934 finissant le 24 mai, les ventes de bovins aux marchés publics se sont chiffrées par 238,166 têtes contre 204,913 pendant la même période de 1933. Les ventes de veaux pendant la période correspondante ont été de 140,611 contre 119,717, celles de moutons de 74,314 contre 77,631 en 1933. Les expéditions de porcs aux marchés publics et directement aux salaisons ont été de 1,339,845 tandis qu'en 1933 pendant cette période il s'est vendu 1,353,323 porcs sur ces marchés.

En avril les ventes de produits agricoles sont tombées à 56.9. L'indice des ventes de grain qui était à 58.7 en mars est descendu à 49.3. Il y a eu une augmentation dans le mouvement des bestiaux, l'indice passant de 86.4 à 90.6.

Au 1er avril l'indice des produits entreposés au froid était de 94.5 puis il s'est élevé à 102.6 au 1er mai, à cause des stocks considérables de beurre, de veau et de volailles, tandis que les stocks de saindoux diminuaient.

Exportations des produits agricoles.—Pendant les douze mois finissant en mars 1934 les exportations de produits agricoles canadiens et végétaux ont été évaluées à $205,804,526 contre $203,370,418 pendant les douze mois finissant en mars 1933. Le volume des exportations des produits agricoles les plus importants pendant cette période est indiqué au tableau suivant.

VOLUME DES EXPORTATIONS DES PRINCIPAUX PRODUITS AGRICOLES CANADIENS PENDANT UNE PÉRIODE DE DOUZE MOIS FINISSANT EN MARS 1933 ET 1934 (1)

Produit	Unité	Valeur		Produit	Unité	Valeur	
		1933	1934			1933	1934
		$	$			$	$
Pommes fraîches	barils	1,780,026	3,476,114	Farine de blé	barils	5,268,371	5,619,937
Conserves de fruits	liv.	9,787,956	17,547,577	Sucre d'érable	liv.	3,176,471	2,295,042
				Graine de trèfle	boiss.	68,121	117,405
Jus de fruits et sirops	gal.	423,168	300,318	Graine de lin	boiss.	371,438	610,327
				Tabac en feuilles	liv.	14,748,069	8,460,639
Pommes de terre	boiss.	1,861,843	2,707,693	Bestiaux	No.	37,359	64,209
Navets	boiss.	1,950,482	1,949,022	Bacon et jambon	qtx.	402,101	960,178
Conserves de légumes	liv.	6,755,112	17,099,688	Bœuf frais	qtx.	50,879	102,771
				Conserves de viande	qtx.	602,966	973,218
Orge	boiss.	9,863,054	1,569,569				
Avoine	boiss.	13,824,742	5,707,502	Fromage	qtx.	857,116	749,669
Seigle	boiss.	8,211,332	2,788,213	Œufs	douz.	270,340	2,122,904
Blé	boiss.	239,378,255	175,534,255	Miel	liv.	2,679,536	2,306,248
Son, gru blanc, gru rouge	qtx.	2,142,785	2,598,860	Laine brute		4,020,751	10,903,821

(1) Sommaire du commerce canadien, mars 1934.

L'examen du tableau qui précède démontre clairement que les exportations de pommes, de conserves de fruits, de pommes de terre, de conserves de légumes, de farine de blé, de graine de lin, de bestiaux, de bacon et de jambons, de bœuf frais, de conserves de viande, d'œufs et de laine ont augmenté. Il y a eu des diminutions dans les jus de fruits et les sirops, l'orge, l'avoine, le seigle, le blé, le sucre d'érable, le tabac en feuilles et le fromage. Parmi ces produits, le blé et le tabac en feuilles sont ceux dont les exportations ont le plus diminué.

Prix aux Etats-Unis.—En mars de cette année l'indice des prix de gros aux Etats-Unis était de 108 (1910–14 = 100) l'indice des prix de ferme pour tous les groupes de produits agricoles était de 74.0 contre 56.0 en avril 1933.

BOOK REVIEW

THE CANKER AND THE DRY ROT DISEASES OF SWEDES. W. Buddin, Brit. Min. Agr. Bull. 74. 1934.

The author gives an account of several years' investigations on two important diseases of swedes, viz, canker and dry rot, both caused by *Phoma Lingam* (Tode) Desm. The former is a disease of the seed-bearing plant, the etiology of which was not previously understood. The most conspicuous symptom is the formation of cankers at the soil line, which are not as a rule noticed until the plants are running to seed. Cankered plants are then easily broken off by the wind or during cultivation. Dry rot is a disease of the swede root crop. In Great Britain it is second to club root in importance, but in New Zealand its ravages have been considerable. Cunningham found that the disease was seed borne and alleged that it could be readily controlled if the seed imported into New Zealand, chiefly of British origin, was disease-free. The present author confirmed Cunningham's finding that the disease was seed borne. However, of the samples of commercial seed tested, about one-quarter showed an infection of 0.2%, while not more than 1 or 2% of the samples have shown as high as 1 to 3%. Moreover the seed possesses a definite fungous flora, and of the seven supposed strains of *P. Lingam* isolated by Cunningham, only two were of this organism, while the others were species of *Macrosporium*, *Alternaria*, *Diplodina*, etc. Three methods of testing for the presence of *P. Lingam* were used: agar plate, sowing in sterilized soil, and the Jacobsen germinator. The latter proved the best as only seed affected with *P. Lingam* became diseased. Cunningham, therefore, appears to have overestimated the extent of seed infection. While the author is of the opinion that seed treatment is of little value, it should be pointed out that certain organic mercury dusts applied at the rate of 6 oz. per bushel did not effect germination and reduced the percentage of diseased seedlings from 30 to 3%.

From observations made by the author and his co-workers, he concludes that sources of infection other than the seed are responsible for outbreaks of these diseases as they occur in England. Sowing of seed in the plant bed or in the field which was in swedes the previous season, leads frequently to serious outbreaks of these diseases. Several weeds including white mustard and charlock were shown experimentally to be susceptible and were found infected in the field. Although the main conclusions of the author may not be altered by subsequent researches, more information is desirable on the persistence of the disease in the soil. —I. L. Connors.

NOTE

The editor of *Scientific Agriculture* regrets that in recent months it has not been possible to publish the magazine at the first of the month and therefore the value of "The Economic Situation" has been lessened to some extent. It is felt, however, that those who do not have access to the sources of information used, or who are unable to find time to read the various publications thoroughly, will appreciate this brief summary of conditions. As soon as the new plans for publication are fully in effect, it is hoped that the magazine will appear at the first of the month and "The Economic Situation" will then possess its customary usefulness.